URBAN TREE CANOPY ASSESSMENTS IN THE CHESAPEAKE BAY WATERSHED

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ABSTRACT

An urban tree canopy assessment (UTCA) is a new technology that can inform management decisions to optimize the economic, social and environmental benefits provided by urban forests. A UTCA uses remote sensing to create a comprehensive spatial snapshot of a locality's land cover, classified at a very fine scale (1 meter or less). Over the past decade, UTCAs have been conducted for numerous localities in the Chesapeake Bay watershed (CBW) as part of a strategy to enhance urban tree canopy (UTC) and reduce stormwater runoff that pollutes the Chesapeake Bay. Our research examined how local governments employ these UTCAs and identified barriers to and drivers of UTCA use for urban forest planning and management. We conducted a web-based survey of all localities in the CBW with populations over 2,500 for which a UTCA existed as of May 2013. We found that 33% of respondents reported being unaware that a UTCA existed for their locality. Even so, survey results showed that localities aware of their UTCA were using it to establish UTC goals, create and implement strategies to achieve those goals, and monitoring progress towards UTC goals. Survey localities were segmented based on how they reported using their UTCA to provide insight on possible outreach and technical assistance strategies that might improve future UTCA use. Overall, we found that larger localities with more developed urban forestry programs use their UTCA more frequently. However, we found several exceptions, suggesting that UTCAs could be an important catalyst for expanding municipal urban forestry programs.

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ATTRIBUTION

Eric Wiseman, PhD, Forest Resources and Environmental Conservation department at Virginia Tech, is currently a professor in Urban Forestry and Arboriculture. Dr. Wiseman was a co-author on this paper and helped with editing and revisions.

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CHAPTER 1 INTRODUCTION

1.1 Background and Justification

In contrast to traditional forestry, where trees in rural areas are managed as a timber resource, in urban forestry, urban trees are primarily managed for ecosystem services. Even though many people do not realize it, we interact daily with urban forests that provide vital ecosystem services including shading of streets and buildings, mitigating air pollution, and enhancing human well-being. There are nearly 4 billion urban trees in the contiguous U.S. providing approximately 27% urban tree canopy (UTC) (Dwyer et al. 2000). UTC is the layer of tree leaves, branches and stems that overhangs the ground in urban areas when viewed from above. To maximize urban forest benefits and minimize costs, localities must manage their urban forests by conserving and enhancing existing UTC.

The urban forestry planning model (Miller 1997) is an adaptive management framework used widely by urban foresters. There are four main stages in the model: (1) resource assessment, (2) goal setting, (3) management plans, and (4) evaluation and feedback. Within urban forest resource assessment, there are two main approaches often referred to as 'bottom-up' and 'top-down'. Bottom-up methods for estimating extent and distribution of UTC include measuring physical dimensions of tree crown spread, visual estimates of overhead tree canopy, or sky-pointed hemispherical photographs (King and Locke 2013). Top-down methods use satellite or aerial imagery of landscapes that is then analyzed by a technician using specialized software to classify land cover and UTC within a defined area.

The urban forestry profession has taken advantage of new advances in remote sensing technology for top-down urban forest resource assessments. Even though urban foresters have been using aerial imagery to assess UTC for decades (Nowak 1992), technology advancements continue to improve the resolution, accuracy, processing time, and costs for performing these assessments. Since the turn of the 21st century, several methods have been used for estimating UTC. The prevailing method, urban tree canopy assessment (UTCA), uses remotely sensed data with one-meter resolution or better and every pixel is classified as either tree canopy or a non-tree land cover classification. A UTCA answers two basic questions: (1) where does UTC currently exist?; and (2) where is additional UTC possible? (Figure 1). UTCAs can be combined with other data such as parcel boundaries or zoning classifications to generate information on the

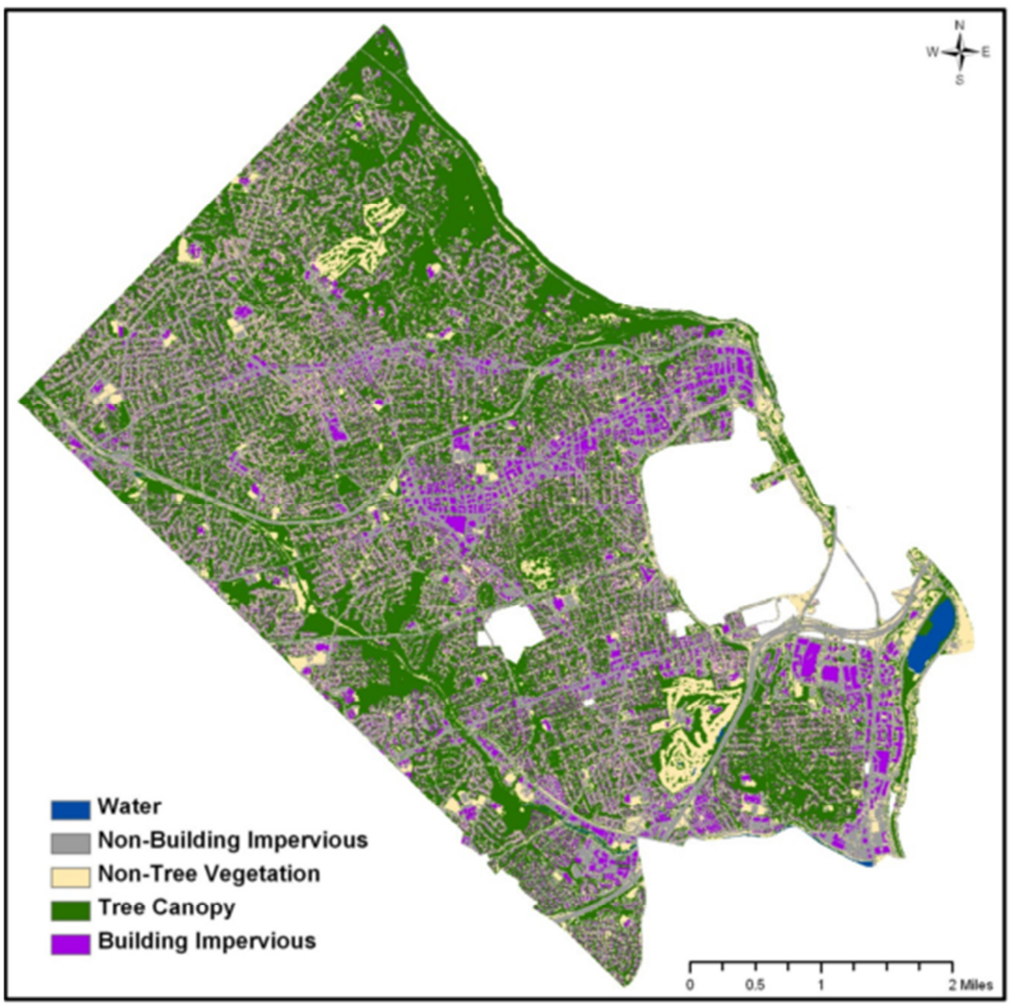

Figure 1 Urban Tree Canopy Assessment for Arlington County, Virginia [public domain] (McKee 2009)

spatial distribution of tree canopy relative to land ownership or land use in an urban area (Rodbell and Marshall 2009; McGee et al. 2012).

Loss of UTC and increase of impervious surfaces within an urban area can have negative environmental consequences such as increased water temperatures, excess nutrients and pollutants in water, and increased stormwater runoff, leading to erosion and flooding in both local and regional watersheds. UTC can mitigate problems associated with urban stormwater runoff by reducing the amount of runoff, lowering water temperatures by shading impervious surfaces, and filtering nutrients and other pollutants by increasing water infiltration rates through soil root channels (Bartens et al. 2008).

With population growth and urbanization projections in the United States (U.S.), urban greenspace is becoming increasingly important for the sustainability and livability of our cities. The Chesapeake Bay watershed (CBW) is an important area ecologically and economically in the Mid-Atlantic region of the U.S. It encompasses over 166,000 km^2 in portions of six states – Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia – and the District of Columbia (Figure 2). The CBW has undergone substantial urbanization and land use change since European settlement. During the last 60 years, the population of the Chesapeake Bay watershed has doubled to its current population of nearly 18 million (Chesapeake Bay Program 2012).

Land conversion and forest cover loss have contributed to high levels of nutrient pollution runoff, leading to decline in the Bay's health. Excess nutrients, particularly nitrogen and phosphorous, can cause increases in algae blooms (some toxic) resulting in very low oxygen conditions that can fall below the level to sustain life in the Bay. Total annual nitrogen input to the Bay has increased six to eight fold and total phosphorus has increased 13 to 24 fold since European colonization (Boynton et al. 1995). The subsequent decline in water quality has had substantial negative impacts on both the environmental and economic uses of the Bay including declining fisheries; three-quarters of the Bay's tidal waters are currently impaired.(Goetz et al. 2004; Chesapeake Bay Program 2012).

Figure 2 Chesapeake Bay watershed map [public domain] (United States Geological Survey 2008)

The Chesapeake Bay Program (CBP) is a regional partnership of federal and state agencies, local governments, non-profit organizations, and academic institutions that is dedicated to restoration and protection of the Bay. Although it is not a regulatory body, each CBP partner uses its own resources to implement Bay restoration and protection activities. In 2007, the CBP identified expanding UTC as a key strategy for Bay restoration. Expanding UTC can be achieved by planting additional trees and by conserving existing trees. The CBP committed to having 120 communities in the CBW develop UTC expansion goals by 2020, and UTCAs have been emphasized as an important tool for establishing UTC goals (U.S. Department of Agriculture 2012).

Because UTCAs evaluate both existing UTC and possible UTC (potential planting space based on non-tree vegetation), they can be used to set realistic UTC goals. A UTC expansion goal typically includes conserving existing UTC plus enhancing UTC on some portion of possible UTC lands. UTCAs identify opportunities for such expansion and help a community identify an achievable goal over a certain timeframe. At a later date, another UTCA can be performed to evaluate the change in canopy and monitor progress toward the UTC expansion goal. As such, a UTCA is a tool that can lead to better informed decisions about urban forest management (McGee et al. 2012; Locke et al. 2013).

New technologies such as UTCAs continue to be developed and improved to facilitate urban forest management, and potential users such as resource managers must choose to use the tool (i.e., adopt it) for it to have any relevance. There has been extensive research about how and why individuals and organizations adopt new tools and technologies and what variables influence their rate of adoption (Jeyaraj et al. 2006). Additionally, categorizing users into typologies based on technology use behavior can improve outreach and marketing (Schwarz et al. 2009), which is critical to expanding the use of UTCAs as a resource planning and management tool. User types reflect different kinds of user skills and motivations.

While there is considerable literature about the adoption of technologies, there is limited research related to urban forestry technology – particularly adoption of UTCA as a planning and management tool. There has been substantial investment in performing UTCAs within the CBW and across the U.S., and information about how UTCAs are being used by practitioners, and why or why not, is important for designing technical assistance and outreach. Given the importance of UTC in mitigating negative environmental effects of urbanization in the CBW and the potential uses of UTCAs in strategically planning and managing the urban forest, we sought to examine how localities within the CBW use their UTCAs.

1.2 Research Goals and Objectives

The ultimate goal of this research was to understand which localities in the CBW have a UTCA and how they have been using them. This information enables us to address whether UTCAs are a functional urban forestry technology and could be helpful for targeting technical assistance to localities that already have a UTCA as well as prioritizing future investment in UTCAs by governmental and non-governmental organizations. To achieve this goal, we pursued four research objectives:

1) Determine how many localities in the CBW have a UTCA.
2) Explore how localities are using their UTCAs.
3) Categorize localities into user typologies based on their use of UTCAs.
4) Analyze the relationship between UTCA use and characteristics of the locality, its urban forestry program, and its UTCA, in order to identify drivers of and barriers to localities using their UTCA.

1.3 Research Framework

In this study, we focused on localities in the CBW because of the recent investment in UTCAs in the region due to CBPs emphasis on UTC expansion for Bay restoration. Part of our study examined only Virginia localities because Virginia accounts for the largest proportion of

CBW population and has been at the forefront of conducting UTCAs. In 2007, Virginia's Urban and Community Forestry program launched the Virginia UTC Project that provided financial assistance and technical support for 26 localities to receive a UTCA (20 of the localities were in the CBW). For localities participating in this project, UTCAs were performed by the Virginia Department of Forestry; the Virginia Geospatial Extension Program at Virginia Tech's Department of Forest Resources and Environmental Conservation; and in consultation with the Center for Environmental Applications and Remote Sensing and the Spatial Analysis Laboratory of the University of Vermont. These UTCAs were completed between 2008 and 2011.

1.4 Research Methods

We use a mixed-methods, multi-phase-approach for collecting both qualitative and quantitative data. In the first phase, we conduct an exploratory survey of localities that participated in the Virginia UTC Project (referred to hereafter as the Virginia survey). We collected qualitative data using an open-ended survey to ground our understanding of the issues related to UTCAs. In the second phase, we expand our study to the entire CBW and surveyed localities in five states and the District of Columbia about UTCA use and their urban forestry program (the CBW survey). Quantitative data were collected using closed-ended questions that were developed based on findings in the first phase, the Virginia survey.

1.5 Thesis Organization

This thesis is organized into five chapters. Chapter 2 provides an overview of the literature pertaining to the benefits of UTC, land cover change in the CBW, UTCAs, and technology adoption by local governments. Chapter 3 presents results from the CBW survey on uses of the UTCAs and frames these uses within Miller's (1997) urban forestry planning model. Additional qualitative information from the Virginia survey is used to contextualize results from the CBW survey. In Chapter 4, we analyze the relationship between several variables and UTCA use. These variables include characteristics of the locality, urban forestry program, and UTCA. We present theories of technology adoption to interpret patterns of use and create user typologies based on how localities report employing their UTCAs. Chapter 5 summarizes our findings and discuss implications of our research for urban forest assessment, planning, and management.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Urban forests are a critical component of the livability and sustainability of modern cities. Urban tree canopy (UTC) cover is one important metric for managing urban forests (Kenney et al. 2011). UTC is the layer of tree leaves, branches, and twigs in an urban area when viewed from above. UTC is generally expressed as a percentage of urban area covered by tree canopy and typically, but not always, a higher percentage UTC is better. Tree functions provide many economic, environmental, and social benefits and measuring UTC is a way to estimate those benefits in a given area.

This chapter begins with an overview of benefits of urban trees and reviews land cover change within the Chesapeake Bay watershed (CBW) study area. Techniques for measuring UTC via urban tree canopy assessments (UTCAs) are then discussed. Finally, theories on technology adoption applicable to the adoption of UTCAs are presented.

2.2 Benefits of Urban Tree Canopy

Urban forests provide municipalities and their citizens a plethora of economic, environmental, and social benefits. Research on urban trees is relatively recent with roughly three quarters of all studies on urban trees published since 2000 (Roy et al. 2012). Benefits from UTC are a result of the functions of trees that people value. Environmental benefits of urban trees, such as stormwater runoff mitigation and improved air quality, also have an economic and a social benefit. Social benefits, such as improved health, also have an economic benefit. A few of the benefits of urban tree canopy are separated below, but ultimately the economic, social, and environmental benefits inter-relate.

2.2.1 Stormwater Runoff Mitigation

Of particular importance for mitigating stormwater is UTC interception of rainfall (McPherson et al. 2005; McPherson et al. 2008). In addition, the root channels from trees also increase infiltration rates through the soil, thus helping reduce runoff in urban areas and increase groundwater recharge (Bartens et al. 2008). Recognizing the functional value of trees to reduce stormwater runoff, some localities, including Philadelphia, have chosen to use trees and other green infrastructure for watershed management in light of the high costs of repairing and expanding a traditional stormwater management system (Silvera Seamans 2013). Furthermore, because trees can reduce the quantity of stormwater runoff, they can be included in municipal strategies to comply with environmental regulations on stormwater (Nowak 2006).

2.2.2 Urban Cooling, Energy Conservation, and Improving Air Quality

Many urban areas struggle to maintain acceptable air quality. Trees can improve air quality in urban areas by both mitigating the creation of pollutants and filtering pollutants out of the air. Cities are typically warmer than the surrounding rural area, a phenomena knows as the urban heat island effect. Hotter temperatures, especially in the summer, means a greater need for cooling buildings thus requiring energy from power plants. Several studies have documented that shade from trees can cool cities enough to have a substantial reduction on peak summer energy needs. McPherson and Simpson (2003) estimated that urban trees in California are responsible for a 10% reduction in summer peak energy demands and that additional strategic plantings on the west side of buildings could save $3.6 billion in cooling needs over 15 years.

In addition to mitigating the creation of pollutants, trees can actually filter out pollutants that are already in the air such as SO_2, NO_2, CO, O_3 and particulate (PM_{10}) (Jim and Chen 2008). It is estimated that urban trees annually filter up to 711,000 metric tons ($3.8 billion value) of polluting gasses and particulate from cities across the U.S. (Nowak et al. 2006). Other researchers modeled potential reductions of up to 40% of NO_2 and 60% of PM_{10}. They also measured reductions of 15% and 23% of NO_2 and PM_{10}, respectively, in London (Pugh et al. 2012). The estimated dollar value of air pollution removal by urban trees for cities like New York City, or Atlanta, Georgia are upwards of $8 million (Nowak 2006). Even in smaller cities such as Washington D.C. or Baltimore, MD, trees provide nearly $2 million, and $3 million, respectively, in annual air pollution removal benefits (Nowak 2006). Recognizing these benefits, the EPA has established several new emerging measures, including tree planting, as part of State Implementation Plans (SIPs) to meet clean air standards (U.S. EPA 2004; Nowak 2006).

2.2.3 Public Health

Recent findings suggest that UTC and urban green spaces can have lifelong health benefits from reducing birth problems (Donovan et al. 2011; Dadvand et al. 2012; Laurent et al. 2013) to reducing rates of disease and illness (Bell et al. 2008; Maas et al. 2009), to increasing longevity (Takano et al. 2002). A study in Portland, Oregon found a significant inverse correlation between increased UTC in neighborhoods and risk of birth weight problems (Donovan et al. 2011). The authors suggested that the cause may be due to lowered stress levels as a result of access to urban green spaces. Maas et al. (2009) showed a correlation between close access to greenspace and reduced instances of several diseases. They found the strongest relationship for diseases such as anxiety and depression. Another recent study from Switzerland suggested that people report decreased levels of stress, fewer headaches, and increased feelings of wellbeing during and after a visit to a greenspace (Hansmann et al. 2007). Furthermore, the positive effects increased with the length of time of the visit. The mechanisms behind these health benefits are unknown, but several of the authors suggest that reduced stress levels, improved environmental quality, and increased physical activity due to access to greenspace may be factors.

2.2.4 Economic Benefits

The economic benefits from urban trees are a result of their desirable functions such as providing shade to lower energy needs or mitigating stormwater runoff thus reducing the need for gray infrastructure needed to handle the runoff. Trees can significantly reduce summertime energy consumption by an average of 31% over a 100 year period because of shading effects (Donovan and Butry 2009). Nationally, urban trees are estimated to provide $3.8 billion annually in air quality benefits alone (Nowak et al. 2006). Furthermore, Hill et al. (2010) estimated that tree canopy preservation through effective public policies could save the average U.S. county between $10 and $15 million annually, with the majority of those benefits from reduced stormwater runoff..

Overall, the returns on investment in trees can be substantial. McPherson et al. (2005) estimated that urban trees in five U.S. cities contribute from $1.37 to $3.09 in benefits for every dollar invested. A study in Lisbon, Portugal reported even higher returns of $4.48 in benefits for each dollar invested, the bulk of which was from increased property value (Soares et al. 2011). Property value increases from trees occur because people tend to aesthetically appreciate trees. In a survey of citizens in Alabama, more than 90% said they “appreciated urban trees in choosing their residential location and community” (Zhang et al. 2007).

2.2.5 Distribution of Urban Tree Canopy Benefits

As UTC changes within an urban area, so do the functional benefits from trees. Therefore, the spatial distribution of UTC is important in determining the location and extent of benefits. For example, Nowak et al. (2006) found variability in air pollution removal because of proximity of tree cover; more tree cover, closer to a sample site, led to greater total pollution removal. Other benefits are similarly localized near where the tree canopy is located. In health studies, one of the predictor variables is percent UTC or greenspace within a certain distance of an individual's home (Donovan et al. 2011; Laurent et al. 2013). The health benefits are localized to residents within a certain proximity to the UTC.

There are a number of drivers of uneven levels of canopy cover. Land use is particularly influential on UTC. For example, whether an area is used for heavy industrial or low density residential tends to correlate strongly with both existing canopy cover and potential planting space (Mincey et al. 2013). Land use is typically linked with zoning because zoning is a tool planners can use to influence land use. As such, different goals and management strategies may be necessary depending on the zoning of an area (Steenberg et al. 2013). For example, researchers in Georgia found that certain tree ordinances, zoning ordinances, and smart growth projects can be effective in preserving tree canopy in communities (Hill et al. 2010).

Furthermore, differences in property ownership or other community group engagement in urban forestry activities can also lead to variability in UTC (Conway et al. 2011; Greene et al. 2011). Heynen and Lindsey (2003) found that socioeconomic factors were significantly correlated with differences in UTC in localities in central Indiana. In a study looking at socioeconomic factors and UTC in Miami-Dade County, researchers found several factors that correlated with differences in UTC including age, income, ethnicity, and rental homes (Szantoi et al. 2012). Decision makers must consider the various drivers of UTC differences, and the importance of spatial heterogeneity and scale of the urban forest for policy and planning purposes.

2.3 Land Cover Change in the Chesapeake Bay Watershed

The once forested Chesapeake Bay watershed (CBW) has undergone high levels of land use change (Goetz et al. 2004). Population in the watershed has more than doubled in the last 60 years to nearly 18 million people and estimates suggest that population growth and urbanization will only continue (Chesapeake Bay Program 2012). Typically, as an area becomes more urban and developed, UTC decreases and impervious surface area increases. Jantz et al. (2005) estimated that between 1990 and 2000, impervious surface area within the CBW increased by 41%. They also estimated that some localities lost as much as 17% of their UTC over the same period. More recent estimates suggest that between 1984 and 2010, the Washington, D.C.-Baltimore, MD region increased in impervious surface area from approximately 3.7% to 4.9% representing an average of 11 km^2 per year. Moreover, the pace of development, and thus increases in impervious surface area, have actually been accelerating (Sexton et al. 2013). One study of land cover change in the CBW predicts an 80% increase in developed land area over the next 30 years (Goetz et al. 2004).

Over large areas, impervious surfaces can increase the temperature of stormwater runoff and volume of stormwater runoff which results in more nutrients and pollutants entering waterways (Jantz et al. 2005). In the CBW, total annual nitrogen inputs to the Bay have increased by six to eight fold and total phosphorus has increased 13 to 24 fold since European colonization (Boynton et al. 1995). This increase is partly due to urban and suburban stormwater runoff (Chesapeake Bay Program 2012). Nutrient runoff in the CBW has a particularly significant impact on the Bay's nutrient status because of the high land area per volume of water ratio, the highest of all estuaries in the United States (Shuyler et al. 1995). Excess nutrients, particularly nitrogen and phosphorous, can cause increases in algae blooms resulting in very low oxygen conditions which can fall below the level to sustain the life of other animals in the Bay.

To address the degradation of the Chesapeake Bay, the Chesapeake Bay Program (CBP) was formed with the mission to lead and direct Chesapeake Bay restoration and protection (Chesapeake Bay Program 2012). The CBP is a partnership that includes federal and state agencies, local governments, non-profit organizations and academic institutions. Though not a regulatory body, each CBP partner uses its own resources to implement Bay restoration and protection activities. The CBP has identified enhancing UTC in the CBW as a key strategy for Bay restoration. In recognition of the importance of UTC, the Chesapeake Executive Council signed Directive #03-01 in 2003, which expanded the CBP goals related to UTC and included the following two objectives relevant to urban forest management:

> *"By 2010, work with at least 5 local jurisdictions/communities in each state to complete an assessment of urban forests, adopt a local goal to increase urban tree canopy and encourage measures to attain the established goals in order to enhance and extend forest buffer functions in urban areas." (Chesapeake Executive Council 2003)*

> *"Encourage increases in the amount of tree canopy in all urban and suburban areas by promoting the adoption of tree canopy goals as a tool for communities in watershed planning." (Chesapeake Executive Council 2003)*

In their guidance document for communities, the CBP recommended UTCAs as a tool for establishing a baseline and setting realistic goals (Raciti et al. 2006) and stated that "in order to establish canopy cover goals, communities need a baseline from which to operate" (Chesapeake

Bay Program 2005). Furthermore, in 2007, the Chesapeake Executive Council committed to have "120 communities develop UTC expansion goals by 2020" (U.S. Department of Agriculture 2012). As a result, there has been substantial investment in performing UTCAs in the CBW in recent years.

2.4 Urban Tree Canopy Assessments

A UTCA is the procedure of measuring, analyzing, and evaluating UTC within a defined geographic area using remote sensing tools and techniques. There are several methods for creating a UTCA but all follow a similar process. Remotely sensed data, including various types of aerial imagery, are acquired for an area and all pixels from this imagery are classified as various types of land cover using computer algorithms. Accuracy assessments are conducted and algorithms are refined until the desired level is achieved (McGee et al. 2012).

For several decades, researchers and resource planners have understood the potential utility of UTC estimates and have been refining methods for more accurate assessment. For example, Nowak et al. (1996) described several methods for estimating UTC from aerial photographs. The authors also provided a table with a list of previously published and unpublished UTC estimates dating from the mid-1970's using best available methods given the technology at the time. Since then, significant advances in technology and data quality have allowed more detailed and higher accuracy estimates of UTC. Walton et al. (2008) provides an in-depth discussion of more current analysis methods and data types. McGee et al. (2012) also detailed several current methods for conducting UTCAs and discussed the benefits and limitations of various data types including high-resolution imagery supported by LiDAR (light detection and ranging) and multi-spectral 1-meter resolution imagery acquired through U.S. Department of Agricultutre's National Agricultural Imagery Program (NAIP).

In the late 1990's and early 2000's there was a call for more accurate mapping to track impervious surface area and forest cover in the CBW. These variables were seen as integral to ecosystem models intended to inform more effective Bay restoration efforts (Goetz et al. 2004). One of the initial goals of UTCAs was to quantify the benefits of urban trees to inform decision makers and help them plan their urban forests (Dwyer and Miller 1999). This is because resource assessment is one of the first steps to creating a successful management plan. Miller (1997) presents an urban forestry planning model with four stages: (1) resource assessment (What do we have?); (2) goal setting (What do we want?); (3) management plan (How do we get there?); and, (4) evaluation of progress (Are we there yet?). Thus, a UTCA is one of the first steps in urban forest management (Eludoyin et al. 2012). Without resource assessment, a community has no basis on which to set achievable goals, draft effective policy, or realistic management plans (Wiseman and McGee 2010). Without baseline data or periodic reassessment as a feedback mechanism to monitor progress toward goals, it is virtually impossible to know if management efforts are working (Dwyer et al. 2000).

The CBP and partner agencies including the Maryland Department of Natural Resources and the Virginia Department of Conservation and Recreation have been very involved in improving maps of UTC and impervious surface area in the CBW (Goetz et al. 2004). Virginia's Urban and Community Forestry program has been particularly responsive to the charge of the CBP to conduct UTCAs and set UTC goals. In 2007, they launched the Virginia UTC Project to provide technical and financial support for 26 localities to conduct UTCAs (McGee et al. 2012).

A UTCA is a tool for assessing the urban forest resource and linking land use to land cover. A UTCA answers two basic questions; where does UTC exist, and where is additional UTC possible? This can be combined with additional data such as parcel boundaries or zoning information to generate information on the spatial density and distribution of UTC within a defined area (Rodbell and Marshall 2009; McGee et al. 2012). With this information, planners and decision makers can establish realistic UTC goals, create effective management plans, and monitor progress. A UTCA facilitates long-range planning by providing analysis of the distribution of the entire urban forest canopy and the ensuing ecosystem services (McGee et al. 2012).

Proponents of UTCAs suggest that they can be used for a variety of activities in urban forest management (Wiseman and McGee 2010). The CBP outlines that these UTC expansion goals should be driven by a UTCA (Raciti et al. 2006). Having accurate and comprehensive information about a locality's UTC is important because many communities have limited budgets and may be more willing to invest in UTC if they understand the economic benefits of that investment (Lewis and Boulahanis 2008). UTCAs, in combination with ecosystem services models, can provide dollar value estimates of the benefits from trees to help inform cost-benefit choices. In a study on municipal officials perspectives on tree programs in Alabama, researchers found that the costs and benefits of trees are a primary concern of decision makers and a better understanding of UTC benefits can lead to more support and buy-in to urban tree programs (Zhang and Zheng 2012). Other researchers have shown that when decision makers such as a city mayor, understand the value of UTC, the urban forestry program for that locality is more likely to be successful (Lewis and Boulahanis 2008).

2.5 Technology Adoption Theories Relevant to Urban Tree Canopy Assessments

A UTCA is a technology innovation and individuals must adopt the technology in order to have any relevance and impact. Numerous theories explain patterns of adoption and implementation of technologies. Two that have been widely used are Diffusion of Innovations

(Rogers 2003) and Technology Acceptance Model (Davis 1989). These two theories provide context for a framework presented by Vonk et al. (2006) that applies to UTCA adoption by local governments

2.5.1 Theory of the Diffusion of Innovations

Rogers published his Diffusion of Innovation (DOI) theory in the early 1960's, grounded in studies of farmers' decisions to adopt new agricultural technologies. Since then, it has become a leading theory in explaining adoption patterns for a variety of technologies including information technology related systems and tools (Mustonen-Ollila and Lyytinen 2003; Völlink et al. 2006). There are a number of components to DOI such as the process by which adoption decisions are made by organizations, characteristics of the technology associated with an individual's adoption decision, variables influencing the rate at which innovations are adopted, and the diffusion process categorizing potential adopters by likelihood and timing of adoption (Rogers 2003).

Diffusion of innovations theory outlines the process by which adoption decisions are made in an organization: 1) agenda-setting, 2) needs-matching, 3) redefining/restructuring, 4) clarifying, and 5) routinizing. In the first two stages, information about the innovation is gathered and the organization plans to adopt or reject the technology. If the organization plans to adopt the innovation then the process continues through the last three stages which make up the implementation phase (Rogers 2003).

According to DOI, five attributes of the technology affect an individual's decision to adopt or reject a technology: (1) relative advantage, (2) compatibility, (3) observability, (4) trialability, and (5) complexity. Relative advantage can be thought of as a comparison of a technology to other tools. Compatibility includes how familiar the innovation is to the potential user based on previous experiences. Observability is the extent to which the innovation can be observed without using it. Trialability is the extent to which a potential adopter can try the innovation out without adopting it. Complexity is how difficult the innovation is to use or understand. These characteristics may lead to a favorable perception of the innovation and a greater likelihood of adoption (Rogers 2003). In a study of predictors of adoption for energy conservation inventions, researchers found that while compatibility was the only strong predictor of adoption, unless the relative advantage was high, potential adopters would not go on to evaluate the innovation on the basis of its other characteristics (Völlink et al. 2006). Therefore, DOI theory would suggest that once localities are aware of UTCA, they begin evaluating it and make a decision to adopt or not. This process can happen numerous times as circumstances and priorities change.

In DOI theory, an important influence on the rate at which an innovation is adopted is the presence or absence of a change agent or champion. A change agent is external to the organization but represents change and innovation in the system and possesses some special knowledge or expertise to increase the rate of adoption (Rogers 2003). For the UTCA, this may be an individual or an organization such as the CBP or a state's Urban and Community Forestry Program that promotes the use of UTCAs and facilitates information sharing on how to use them. In a study on factors influencing local governments to adopt environmentally oriented programs, Vasi (2007) found links to national or international change agents to be significant factors.

Rogers also suggests that there is a normal distribution of adoption of a technology through time, known as the technology adoption curve. In the technology adoption curve, adopters are categorized based on when they adopt an innovation starting with early innovator, then early adopter, then early majority, then late majority, and followed by laggards. For example, the first localities to perform and use a UTCA would be considered early innovators. It is not an inevitability that a technology will 'complete' the technology adoption curve and be adopted by all potential users. Some technologies fail to achieve widespread adoption and others may be initially adopted and then later rejected in favor of a new technology or some other reason.

2.5.2 Technology Acceptance Model

Roger's DOI theory has gained widespread acceptance and application since it was first published in the early 1960's. In the ensuing decades, several other social scientists have developed models and theories to improve our ability to understand and predict different behaviors such as the adoption of a technology. The Technology Acceptance Model (TAM) suggested by Davis et al. (1989) was developed specifically to understand and predict user acceptance of various computing technologies. It is useful in understanding how a technology gets accepted by users within an organization that has adopted the technology (Figure 3).

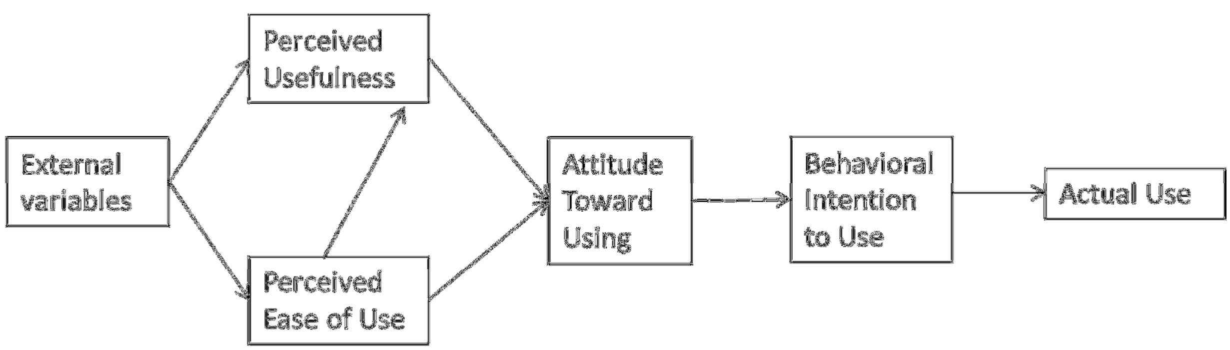

Figure 3 Technology Acceptance Model (TAM). Perceived usefulness and perceived ease of use are important predictors of actual use of a technology (Davis et al. 1989).

According to Venkatesh and Davis (2000), TAM consistently explains a substantial proportion (around 40%) of the variance in usage of a technology when tested in the literature. The external variables that influence ease of use and perceived usefulness in TAM are only loosely defined in Davis et al.'s model. The two main measurements that predict actual use are perceived usefulness of a technology, and perceived ease of use of that same technology. Davis (1989) defines perceived usefulness as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance", and perceived ease of use as "the degree of ease associated with the use of the system" (Davis 1989). Both components are positively correlated with actual use of a technology (Venkatesh and Davis 2000). Therefore, TAM suggest that users such as practitioners in local government, that perceive the UTCA to be more useful and easier to use will be more likely to use the UTCA.

2.5.3 Framework for Understanding Bottlenecks in Technology Adoption

To explain patterns of adoption of UTCAs by local governments, we use a framework presented by Vonk et al. (2006). This framework was developed by examining planning support system (PSS) adoption in Dutch planning agencies and is useful for understanding low levels of adoption commonly found in geo-information technologies. The framework includes three perspectives from which to view barriers to the adoption of a technology like UTCAs: (1) instrument approach, (2) user approach, and (3) transfer approach. All three approaches provide useful insight into technology adoption; Vonk et al. (2006) found evidence of all three in their study.

In the 'instrument approach', the problem lies in the instrument. This could be due to poor functionality or simply because it does not match the needs of the user. This can be related to both the DOI concept of 'relative advantage' and TAM's concept of 'perceived usefulness'. Ultimately, if the technology does not address any needs of a user or improve upon what they are currently using, they will have no reason to use it.

In the ‘user approach’, the problem is the user having some blockage in the adoption process. There have been several models developed to help predict whether a user will decide to adopt or not—the adoption process—such as TAM (Davis 1989) and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al. 2003). These models are based on numerous and sometimes disparate variables. In a review of information technology adoption predictors, Jeyaraj et al. (2006) categorizes 135 variables that have been theorized or tested in the literature into four main groups. The first group is characteristics of the individual such as the person’s age or experience with a similar technology (Rogers 2003). The next one is characteristics of the technology such as ease of use, perceived usefulness, or data characteristics (Göçmen and Ventura 2010). The third is characteristics of the organization including, organization size, available funding, and level of staff training (Cohen and Levinthal 1990; Lewis and Boulahanis 2008; Göçmen and Ventura 2010; Zhang and Zheng 2012). The final group is environmental characteristics such as external pressure to adopt the technology, location and socioeconomic composition of the potential adopter’s environment (Vasi 2007; Lewis and Boulahanis 2008; Zhang and Zheng 2012).

The final perspective in Vonk et al.’s framework is the ‘transfer approach’ where the problem lies in the flow of information about the technology. This approach looks at the diffusion and adoption of a new technology as a whole. This perspective incorporates the DOI concept of a technology adoption curve in which adoption follows a normal distribution through time (Figure 5) (Rogers 2003). From this perspective, if a technology is under-used, the diffusion process has only reached the first groups in the technology adoption curve. Additionally, this perspective acknowledges the role of a change agent, again assimilating DOI.

A change agent can affect the rate of adoption of a technology by overcoming bottlenecks of the spread of information about a technology.

2.6 Summary

In this chapter, we have reported on the importance of urban tree canopy and a few of the key benefits that urban trees provide in order to build the rationale for managing urban forests. UTC has declined within the CBW and efforts are underway to address this problem as part of a strategy to restore the Chesapeake Bay. UTCAs have become an important urban forestry planning tool over the last two decades and their application for conserving and enhancing UTC is becoming more important. There are several theories in the literature that are relevant to the adoption of UTCAs by local governments and can be used to understand observations of UTCA use and perceived usefulness by localities. In the next chapters, we will explore the adoption of UTCAs by localities in the CBW to understand how UTCAs can inform urban forest management to create more sustainable and resilient cities.

CHAPTER 3 USE OF URBAN TREE CANOPY ASSESSMENTS IN THE CHESAPEAKE BAY WATERSHED

3.1 Introduction

The Chesapeake Bay watershed (CBW) has undergone substantial urbanization and land cover change since European settlement. The CBW covers portions of six states (Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia) and the District of Columbia, encompassing over 166,000 km^2 and inhabited by nearly 18 million people (Chesapeake Bay Program 2012). As a result of land conversion and loss of forest cover, high levels of nutrient and pollution runoff have led to a decline in the Bay's health and subsequent degradation of both its environmental and economic uses (Goetz et al. 2004; Chesapeake Bay Program 2012). Population growth is one of the leading drivers of land cover change in the CBW and the population has more than doubled over the past 60 years (Chesapeake Bay Program 2012). Typically, as an area becomes more developed, urban tree canopy (UTC) decreases and impervious surface area increases (Nowak and Greenfield 2012). Jantz et al. (2005) estimated that impervious surface area within the CBW increased by 41% between 1990 and 2000, with some localities losing as much as 17% of their UTC during that period. More recently, Sexton et al. (2013) reported that between 1984 and 2010, impervious surface in the Washington, D.C. and Baltimore, MD region increased from approximately 3.7% to 4.9% (an average increase of 11 km^2 per year), and the pace of development is currently accelerating.

Loss of UTC and increase in impervious surface within an urban area can have negative environmental consequences for both local and regional watersheds. Impervious surface increases both temperature and volume of stormwater runoff (Jantz et al. 2005) and carries pollutants to the Bay from urban and suburban areas (Goetz et al. 2004). Conversely, UTC can reduce stormwater runoff temperatures while tree roots and soil can filter out nutrients and other pollutants. Nutrient runoff in the watershed has a particularly significant impact on the Bay's nutrient status because of the high land area per volume of water ratio, the highest of all estuaries in the United States (Shuyler et al. 1995). Tree canopy reduces stormwater runoff not only by intercepting rainfall, but tree root channels also increase infiltration rates through the soil, thus helping reduce runoff in urban areas and potentially increasing groundwater recharge (Bartens et al. 2008). UTC can also provide municipalities and their citizens with other economic, environmental, and social benefits (Roy et al. 2012); however, as the distribution of UTC changes within an urban area, so do the functional benefits. Therefore, the distribution of UTC is important in determining the location and magnitude of benefits. For example, Nowak et al. (2006) found variability in air pollution removal across their study cities because of the amount of UTC at their sample sites; more tree cover in an area led to greater total pollution removal in that area.

In the late 1990's and early 2000's, interest increased for more accurate mapping of land cover to track impervious surface area and forest cover in the CBW. These data were seen as integral to ecosystem models intended to inform effective Bay restoration efforts (Goetz et al. 2004). UTCAs were developed to help decision makers understand their urban forest resource. UTCAs evaluate UTC within a defined geographic area using remote sensing tools and techniques (McGee et al. 2012). Several dozen UTCAs have been performed for municipalities across the U.S. over the past decade and many of those have been in the CBW. A UTCA answers two basic questions: (1) where does UTC currently exist? and (2) where is additional UTC possible? This data can be combined with existing geographic information such as parcel boundaries or zoning to generate information on the distribution of UTC within a defined area

(Rodbell and Marshall 2009; McGee et al. 2012). Municipal planners and decision makers can then establish data-driven UTC goals; create and implement strategies to achieve those goals; and monitor and evaluate progress toward those goals.

The Chesapeake Bay Program (CBP), a regional partnership dedicated to restoration and protection of the Bay, identified expanding UTC as a key strategy to improve Bay health. The CBP, which includes federal and state agencies, local governments, non-profit organizations, and academic institutions, has committed to facilitating the establishment of UTC expansion goals in 120 communities in the CBW by 2020 (USDA Forest Service 2012). Though not a regulatory body, the CBP encourages “increases in the amount of tree canopy in all urban and suburban areas by promoting the adoption of tree canopy goals as a tool for communities in watershed planning” (Chesapeake Executive Council 2003). UTCAs are viewed as essential for establishing UTC goals (Raciti et al. 2006). Each CBP partner uses its own resources to implement Bay restoration and protection activities. As such, the implementation of UTCAs has been left up to each state’s Urban and Community Forestry program. Each state decides how to engage communities in conducting and employing UTCAs (Julie Mawhorter, personal communication, Jan. 28, 2013).

We conducted our exploratory research in Virginia to ground our understanding of the issues. Of all the states, Virginia accounts for the largest proportion of land area and population in the CBW and nearly 75% of its population lives there (US Census Bureau 2012). The Virginia UTC Project was launched in 2007 to provide technical and financial support for 26 localities to conduct UTCAs (McGee et al. 2012).

Though there has been substantial investment in performing UTCAs within the CBW and across the U.S., there has been little investigation as to how they are employed by local governments. The limited existing research has primarily been focused on demonstrating how localities could use UTCAs as decision-support and planning prioritization tools (Locke et al. 2010; McGee et al. 2012; Locke et al. 2013) and for informing policy (Raciti et al. 2006; Wiseman and McGee 2010). However, it is not evident how the tool is being used by local governments more broadly. The purpose of this research was to determine how many localities in the CBW have UTCAs and study how UTCAs are used for activities such as establishing UTC goals, creating and implementing strategies to achieve those goals, and monitoring progress.

3.2 Methods

3.2.1 Survey 1: Localities Participating in the Virginia UTC Project

To understand how localities in the CBW use UTCAs, we first conducted exploratory research in Virginia to ground our understanding of the issue. We surveyed 26 Virginia localities that participated in the Virginia UTC Project, 20 of which are located in the CBW, and requested open comments regarding how they use their UTCAs (the Virginia survey). The web-based Virginia survey was administered between December 2012 and January 2013. To get the broadest response, the survey was sent to multiple people from each locality with one person representing each of the following roles: urban forester or natural resources manager, local planner, GIS specialist, and a public administrator overseeing local environmental programs. Contact information was gathered through websites or by calling. In some small localities, a single person may have qualified for multiple roles.

To maximize response, the survey was administered according to the modified Dillman Total Design Method including an introduction email requesting participation, the survey, and two follow up reminders (Dillman 2000). The survey asked the open-ended questions, “Describe how your locality is using its urban tree canopy assessment (UTCA)” and, “in addition to any current uses, describe some ways that you think your locality should use its UTCA”. Open-ended questions were used to capture input from respondents in order to improve depth of understanding about the extent and sophistication of UTCA use (McLean et al. 2007). Responses to open-ended questions were open coded to create a list of potential uses of UTCAs.

The results of this survey were used in two ways. First, the list of potential uses was modified by urban forestry professionals familiar with UTCAs and included in the subsequent quantitative survey of all localities in the CBW with UTCAs (the CBW survey). Secondly, selected responses have been used in the results and discussion section of this paper as examples to contextualize quantitative CBW survey results.

3.2.2 Survey 2: Localities in the Chesapeake Bay Watershed

We used ArcGIS Explorer Online (Esri, Redlands, CA) and U.S. Census Bureau data to identify a total of 440 localities, including 165 counties, 87 cities, and 188 towns with populations over 2,500 that had land area either partly or completely within the CBW (ESRI 2013; US Census Bureau 2013). Simultaneously, we developed a list of localities with completed UTCAs as of May 2013 by contacting the Urban and Community Forester for each state, the CBP, and universities and private companies known to have performed UTCAs. We then crosschecked the list of localities in the CBW with the list of localities with completed UTCAs. We identified 55 UTCAs covering 101 localities (see Appendix A for the list) including 12 counties, 42 cities, and 47 towns. Localities with UTCAs represented 9.2% of the land area within the CBW.

Due to differences in administrative subdivisions between the states, we chose to group localities into three categories: county, city, and town. For the purposes of analysis, boroughs (PA) were considered towns, and corporations (WV) and districts (DC) were considered cities. We made no distinction between independent cities and regular cities. Townships, a sub-county level administrative unit in PA, were excluded because they are typically small (<10,000 people), lack more than a few employees, and do not have an equivalent administrative unit in other states. There were no localities in the CBW portion of New York with UTCAs.

3.2.2.1 Survey Respondents

For each locality, we identified one respondent to complete the survey via either a search of the locality's website or by calling the locality. The ideal individual to complete the survey was knowledgeable (or most knowledgeable) about use of the UTCA; had a broad understanding of the urban forestry program (if any) within the locality; held a planning or management position; or could make decisions in an official capacity about use of the UTCA. Depending on the locality, the official role of the ideal respondents varied from urban forester, arborist, planner, or the town or city manager. To confirm that the most qualified individual had been identified, the person was contacted via telephone to discuss their attributes and willingness to participate. Of the 101 localities contacted in the CBW, three stated during phone conversations that "matters of trees or land use planning" were dealt with at the county level and did not wish to receive a survey.

3.2.2.2 Survey Design

The web-based CBW survey included an initial screening question asking whether respondents were aware of their locality's UTCA. If they responded 'no', it was assumed the UTCA was not being used by the locality. Because we had documentation that a UTCA had been performed in each locality, we were confident that an assessment existed, though the locality may not have had access to or been aware of the data at the local level. Localities that indicated that they were unaware of their UTCA were only asked questions related to their urban forestry program (See Appendix B for urban forestry program data).

A list of 17 potential uses of UTCA was created from the open-coded responses of the Virginia survey and modified with input from urban forestry professionals familiar with UTCAs (Table 1). CBW survey respondents who indicated that they were aware of their UTCA were then asked if their locality was using it for each of the 17 activities. The respondents could reply "Yes", "No", or "Don't Know" about their locality using of the UTCA for each activity. We piloted the survey with several urban forestry professionals to identify and correct ambiguities and refine questions. The survey was administered online in July 2013, using the Qualtrics Research Suite (Qualtrics, Provo, UT) and again following Dillman's (2000) method as described above.

Potential uses of the UTCA were categorized based on the four stages of the urban forest planning model as described by Miller (1997): (1) resource assessment; (2) goal setting; (3) management plans; and, (4) evaluation and feedback. These stages correspond with conducting a UTCA, (2) UTC goal setting, UTC implementation strategies, and UTC monitoring and evaluation (Table 1). We further divided Stage 3—UTC Implementation Strategies—into three categories based on the types of activities that emerged from responses to the Virginia survey: (1) public buy-in, (2) prioritization, and (3) policies and land use planning.

Table 1 List of 17 potential uses of an urban tree canopy assessment (UTCA) asked about in Chesapeake Bay watershed survey. Potential uses contextualized with examples from the Virginia survey responses and categorized based on stages in Miller's (1997) urban forestry planning model.

Stages		17 Potential Uses of UTCA	Excerpts from Virginia Survey Responses
UTC Goal Setting		Create a locality-wide tree canopy goal	*"the assessment was considered when setting a UTC goal"*
UTC Goal Setting		Develop tree canopy goals based on land-use, zoning or other fine-scale criteria	*"setting canopy goals based on land-use types and available planting spaces"*
UTC Implementation Strategies	Public Buy-In	Educate public officials or citizens about the importance of tree canopy	*"information is being used in education of public officials about value of trees"*
UTC Implementation Strategies	Public Buy-In	Engage the public with local urban forestry (e.g. volunteer recruitment, partnerships)	(no relevant excerpts)
UTC Implementation Strategies	Public Buy-In	Leverage additional funding or justify funding requests	*"used in attempt to obtain funds for maintenance of existing trees on public right of ways"*
UTC Implementation Strategies	Prioritization	Plan and prioritize tree plantings	*"identify potential locations where trees may be planted to increase city canopy coverage"*
UTC Implementation Strategies	Prioritization	Plan and prioritize tree canopy conservation	(no relevant excerpts)
UTC Implementation Strategies	Prioritization	Plan and prioritize outreach to specific neighborhoods or districts based on tree canopy cover	*"targeting neighborhoods with lower tree canopy for outreach…and for participation in various programs to get more trees planted on private property"*
UTC Implementation Strategies	Policies and Land Use Planning	Inform larger initiatives (e.g. sustainability plans, watershed implementation plans, green infrastructure plans, comprehensive plans)	*"included the analysis in the updated comprehensive plan and hope to use it in some way to promote additional vegetative cover"*
UTC Implementation Strategies	Policies and Land Use Planning	Inform land use planning and zoning with appropriate green infrastructure considerations	*"identify opportunities to mitigate fragmentation of woodland and forest communities through reforestation"*
UTC Implementation Strategies	Policies and Land Use Planning	Guide requirements for tree conservation during site development and re-development	(no relevant excerpts)
UTC Implementation Strategies	Policies and Land Use Planning	Inform creation or revision of policies such as zoning, taxation, tree ordinances	*"revisions to the existing zoning ordinances requiring a greater level of tree canopy for new construction of residential and commercial properties"*
UTC Implementation Strategies	Policies and Land Use Planning	Enforce tree ordinances or site development requirements	*"help monitor the effectiveness of our local tree conservation ordinance during land development"*
UTC Assessment and Monitoring		Provide a baseline for evaluating progress toward tree canopy goals	*"it gives us a good benchmark of existing conditions so that we have something to measure our success by in 10 years"*
UTC Assessment and Monitoring		Evaluate potential impacts of tree canopy gains or losses	*"[environmental benefit estimates] are used for economic development purposes as well as measuring environmental improvement"*
UTC Assessment and Monitoring		Demonstrate compliance with air quality management goals or requirements (e.g. SIP)	(no relevant excerpts)
UTC Assessment and Monitoring		Demonstrate compliance with stormwater management goals or requirements (e.g. MS4s, WIP)	*"to determine stormwater management potential in areas designated by Chesapeake Bay Protection Act and subject to TMDL requirements"*

3.3 Results and Discussion

3.3.1 Survey Responses

3.3.1.1 Virginia Survey

Initially, 121 individuals from 26 localities in Virginia were contacted; however, 42 individuals indicated that someone else we already contacted was more qualified to respond. Of the remaining 79 individuals, we received 58 completed surveys for a 73% response rate (in several instances, multiple individuals per locality). Of the 58 individual respondents, we identified 32% as resource managers, 27% as planners, 22% as GIS specialists, and 20% as administrators based on their job title. At least one individual responded to the survey for 24 of the 26 localities, yielding a 92% response rate from the localities. Responding localities ranged in size from 4,895 to 437,994 people and had a population density from 243 to 3,208 people/km^2.

3.3.1.2 Chesapeake Bay Watershed Survey

Of the 98 surveys that were sent out, 55 were returned yielding a 56% response rate. Four surveys were not usable and thus excluded from further analysis. In total, 51 completed surveys representing 24 cities, 9 counties, and 18 towns were analyzed. Response bias at the 95% confidence level was not observed across state, locality type, or population size. Responding localities represented about 81% of the total land area of localities with UTC assessments and about 7% of the total land area of the CBW and included a cross-section of population sizes and densities (**Error! Reference source not found.**).

Table 2 Minimum, median, and maximum land area, population, and population density for 51 Chesapeake Bay watershed localities that responded to the survey regarding use of their urban tree canopy assessment.

	Minimum	Median	Maximum
Land area (all localities) | km²	**1**	**249**	**2,458**
Land area (towns)	1	13	44
Land area (cities)	5	106	906
Land area (counties)	544	1,093	2,458
Population (all localities) | people	**2,548**	**130,815**	**1,081,726**
Population (towns)	2,548	9,488	42,616
Population (cities)	5,259	115,840	620,961
Population (counties)	53,498	413,404	1,081,726
Population density (all localities) | people/km²	**78**	**1,108**	**3,976**
Population density (towns)	158	969	1,968
Population density (cities)	243	1,491	3,976
Population density (counties)	78	367	1,057

3.3.2 Awareness of Assessments in the Chesapeake Bay Watershed

Only 34 of the 51 (67%) respondents in the CBW survey indicated they were aware that a UTCA had been performed for their locality. County respondents seemed to be the most aware, with eight of the nine being aware, whereas only one-third of town respondents were aware (Table 3). We were surprised by the substantial proportion (33%) of respondents that were unaware of their locality's UTCA. Because this was unexpected, the survey was not designed to identify reasons that respondents may be unaware of their localities' UTCA. However, we propose a few potential explanations: (1) no one was informed that the assessment had occurred; (2) the information was disregarded or not effectively disseminated across key departments within the locality, perhaps due to lack of awareness or expertise about urban forestry within the locality; (3) lack of "institutional memory" of the UTCA because of a significant change in staffing or record-keeping since the time of the UTCA; or (4) the survey respondent was not the appropriate individual to contact and was not aware that other individuals or departments within the locality were using the UTCA.

We made efforts to reduce the likelihood of the last potential explanation by asking initial contacts for additional contacts if they did not have responsibility for the UTCA. Based on our knowledge of the origins of the UTCAs, we attribute some of this lack of awareness to the fact that several UTCAs were conducted at the county-wide scale, and therefore it is possible for data to exist for some towns without the town's participation or knowledge. Though we cannot assume that these smaller localities would use the UTCA even if they were aware of it, we did find some small localities were using their UTCA suggesting that it is possible. The need to engage smaller localities that already have UTCAs conducted at the county-level is clear. It is evident that additional efforts should focus on communicating potential usefulness of existing UTCAs.

Table 3 Percent (and count) of localities in the Chesapeake Bay watershed survey that were aware of their urban tree canopy assessment sorted by state and locality type.

State	Locality Type			
	County	City	Town	Grand Total
District of Columbia	N/A[1]	100% (1)	N/A	**100% (1)**
Delaware	N/A	0% (0)	100% (1)	**50% (1)**
Maryland	100% (5)	92% (11)	50% (2)	**86% (18)**
Pennsylvania	100% (1)	50% (1)	11% (1)	**25% (3)**
Virginia	100% (1)	86% (6)	50% (2)	**75% (9)**
West Virginia	50% (1)	100% (1)	N/A	**67% (2)**
Grand Total	**89% (8)**	**83% (20)**	**33% (6)**	**67% (34)**

[1] N/A – Locality type was not represented in this survey for this state.

3.3.3 Uses of Urban Tree Canopy Assessments

Only respondents that said they were aware of their locality's UTCA were asked whether or not their locality had used their UTCA for each of the 17 pre-defined activities (Table 1). The most frequently reported uses included: *educating officials or citizens about the importance of tree canopy* (57%), *providing a baseline for evaluating progress toward UTC goals* (49%), *creating a locality-wide tree canopy goal* (47%), *planning and prioritizing tree plantings* (45%), *and informing larger initiatives* (43%). Observed patterns in the results were used to create a conceptual model separating activities into general and specialized uses within each stage of the urban forestry planning model (**Error! Reference source not found.Error! Reference source not found.**). For example, localities that reported a specialized use of their UTCA were also reported performing the general use within the same stage of the planning model. About one-third of localities reported six or more uses of the UTCA.

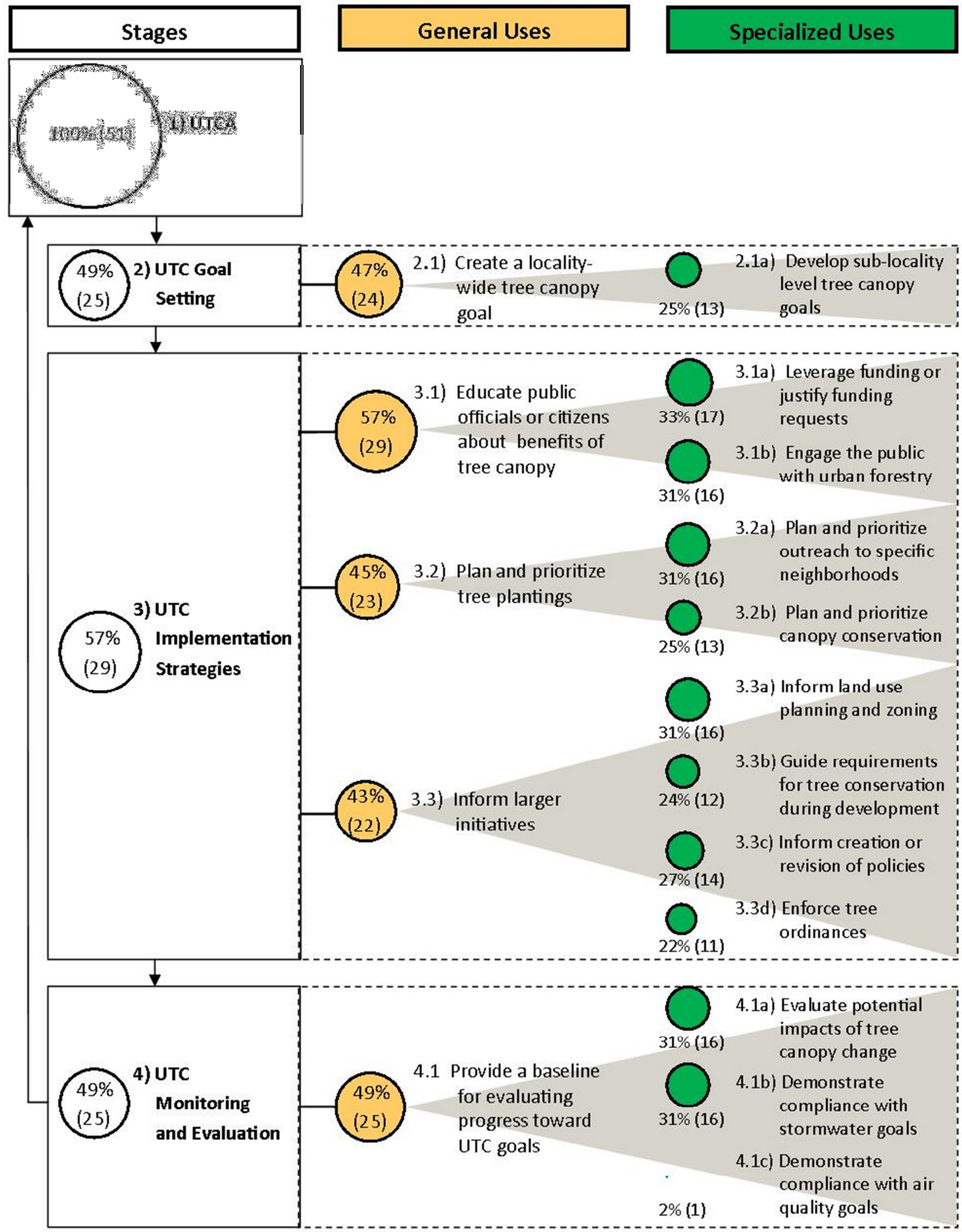

Figure 4 Percent (and count) of localities using their urban tree canopy assessment (UTCA) for 17 activities. Circle size is proportional to the number of localities. Activities categorized by stages of the urban forestry planning model (Miller 1997). General and specialized activities separated within each stage based on observations that localities using their UTCA for a specialized activity also reported performing the general activity within the same stage.

3.3.3.1 Urban Tree Canopy Goal Setting

Forty-seven percent of the CBW survey respondents stated that their locality had used the UTCA to *create a locality-wide tree canopy goal*. While most respondents to the Virginia survey simply mentioned that the UTCA was considered in goal setting, one said that the assessment was used to "calculate how many trees will need to be planted to attain our stated goal" in order to determine if the goal was achievable. An important part of setting realistic and achievable goals for urban tree canopy is to understand the existing and possible UTC and the resources required to achieve those goals. For example, in 2007, the city of Charlottesville, VA set a UTC goal of 40%; however, in 2009, results from a UTCA of the city based on 2007 data showed that UTC in the city was actually over 46% (City of Charlottesville 2009). This illustrates the need for data-driven goals in decision-making.

Even fewer respondents, 25%, reported that their locality was using the UTCA for in-depth goal setting to *develop tree canopy goals based on land-use, zoning or other fine-scale criteria*. Because several factors correlate with UTC, such as socioeconomic status and land use, it may be worthwhile to create sub-locality goals for particular areas based on land use, environmental data, or socioeconomic characteristics. Szantoi et al. (2012) argued for localized UTC goals that take into account socioeconomic variability across different areas. Similarly, American Forests, a nonprofit advocacy group, suggests adjusting UTC goals based on land use types: 50% UTC in suburban residential; 35% in urban residential; 25% in commercial and mixed use or industrial; and 15% in central business districts (American Forests 2008). Finer-scale goals are recommended because different land uses and land use densities (for example, suburban versus high-density residential) typically have both different existing and possible UTC (Mincey et al. 2013).

3.3.3.2 Urban Tree Canopy Implementation Strategies

3.3.3.2.1 Public Buy-in

In the CBW survey, 57% of the localities indicated that they were using the information from the UTCA to *educate public officials or citizens about the importance of tree canopy*. When decision-makers understand the value of urban tree canopy, the urban forestry program for that locality is more likely to be successful (Lewis and Boulahanis 2008). Moreover, the spatial distribution of UTC can provide decision makers with additional information to support policy development that addresses the drivers of uneven UTC distribution. Respondents to the Virginia survey made statements about using the assessment for education such as, “the UTC [assessment] is used for public education and outreach on the state of [our] urban forest and the value of trees”.

Use of the UTCA for more complex public engagement purposes was not as common among CBW survey respondents; 31% of respondents reported using the UTCA to *engage the public with local urban forestry (e.g., volunteer recruitment or partnerships).* Public participation in achieving UTC goals is often essential for success. In Baltimore, for example, as of 2007 the city had 27% UTC but a goal of 40% by 2040. The UTCA showed that private residents owned the majority of existing UTC and the majority of tree planting spaces for additional canopy. Therefore, in order to achieve the stated UTC goal, the city needs to engage residents in the goal and inform them of the importance of their contribution to UTC conservation and enhancement (O'Neil-Dunne 2009; Locke et al. 2013).

Only 33% of respondents stated that their locality was using the UTC to *leverage additional funding or justify funding requests*. Because communities have limited budgets, policy makers may be more willing to invest in UTC if they understand the economic benefits of that investment for their constituents (Lewis and Boulahanis 2008). One respondent to the Virginia survey said that "UTC information is being used in an attempt to obtain funds for maintenance of existing trees on public right of ways". Localities may also find their UTCA useful for writing competitive grant applications and substantiating internal funding requests. For example, St. Louis, MO is using its UTCA to raise awareness about the benefits of its urban forest and leverage additional funding for a broader St. Louis regional UTCA (Coble and Walsh 2012).

3.3.3.2.2 Prioritization

Results from the CBW survey showed that 45% of localities were using the UTCA to *plan and prioritize tree plantings*. Typical responses from the Virginia survey suggests that there is an opportunity for more sophisticated prioritization techniques beyond simply identifying available planting space that will, as stated by one respondent, have "the greatest impact on our overall UTC percentage". The benefit of increasing overall UTC in a city is tied to the environmental and social benefits trees provide; as such, an opportunity exists to prioritize tree plantings to maximize benefits rather than simply to increase UTC for its own sake. Locke et al. (2010) described how New York City's UTCA can be used to prioritize tree plantings to mitigate various issues within a city including flooding, noise pollution, and public health challenges. UTCAs also can be used to prioritize conservation of existing tree canopy in comprehensive plans or other regional greenspace planning. Surprisingly, we found that substantially fewer localities, 25%, were using their UTCA to *plan and prioritize canopy conservation*, suggesting this may be a more complex activity.

Additionally, 31% of CBW localities were using the UTCA to *plan and prioritize outreach to specific neighborhoods or districts based on tree canopy cover*. One Virginia respondent said their locality was using their UTCA “for targeting neighborhoods with lower tree canopy for outreach and awareness on the value of planting and preserving trees...and to target those areas for participation in various programs”. Across the country, other communities are using their UTCA for prioritization. For example, the Indianapolis Neighborhood Woods Planting prioritized neighborhoods with low UTC and high available planting space (Wilson and Lindsey 2009). Other cities like St. Louis, MO are using their UTCAs to prioritize tree planting locations for a tree planting plan (Coble and Walsh 2012).

3.3.3.2.3 Policies and Land Use Planning

Resource managers can only directly manage trees (e.g., plant and maintain trees) on municipal public land including right-of-ways, parks, and grounds of public buildings. Since the majority of land in urban areas is often private residential, commercial, or industrial lands, resource managers must use a different suite of tools to indirectly manage trees on these lands. Among these tools are various policies and incentives such as comprehensive plans, zoning ordinances, tree ordinances, and development credits, some of which have been shown to have an effect on UTC (Hill et al. 2010). In our study, 43% of CBW localities were using their UTCA for the general activity to *inform larger initiatives (e.g. sustainability plans, watershed implementation plans, green infrastructure plans, and comprehensive plans).* Fewer, 31%, said they used the UTCA specifically *to inform land use planning and zoning with appropriate green infrastructure considerations*. As an example, one Virginia survey respondent said they were using their UTCA to “identify opportunities to mitigate fragmentation of woodland and forest communities through reforestation”.

Researchers in Georgia found that certain tree ordinances, zoning ordinances, and smart growth projects can be effective in preserving UTC in communities (Hill et al. 2010). In the

CBW survey, 27% of respondents reported that their locality used its UTCA to *inform the creation or revision of policies such as zoning or tree ordinances*. One Virginia survey respondent stated that their locality is in the process of “revisions to the existing zoning ordinances requiring a greater level of tree canopy for new construction of residential and commercial properties.” Also in the CBW survey, 24% of respondents reported the use of their UTCA to *guide requirements for tree planting or canopy preservation during site development*. A Virginia survey respondent illustrated this activity by stating their locality was using it “to increase new landscaping zoning ordinances on private property.” We found 22% of CBW localities reported using the UTCA to *enforce tree ordinances or site development requirements*. With follow-up UTCAs, it is possible to compare UTC change through time and evaluate the effectiveness of various policies such as tree protection ordinances (McGee et al. 2012).

3.3.4 UTC Monitoring and Evaluation

One of the most basic, yet informative uses of a UTCA is developing a baseline for a locality’s UTC in order to evaluate future changes and monitor progress toward UTC goals. Without baseline data and periodic reassessment as a means to monitor progress toward goals, it is virtually impossible to know if management efforts are working (Dwyer et al. 2000). Nearly half, 49%, of respondents to our CBW survey said their UTCA was used to *provide a baseline for evaluating progress toward tree canopy goals*. One respondent to the Virginia survey said, “the UTCA not only gives us guidance where trees are needed, but it gives us a good benchmark of existing conditions so that we have something to measure our success by in 10 years or more.” Multiple UTCAs must be conducted over time to evaluate change in UTC at the locality-wide and finer scales.

Once UTC is known, decision makers can model economic impacts for scenarios in which UTC increases or decreases and weigh the costs and benefits of various management options. In the CBW survey, 31% of localities reported using their UTCA to *evaluate potential impacts of tree canopy losses or gains*. The UTCA could also be used to assess the economic impacts of natural disturbances such as major storms or outbreaks of an invasive pest.

UTCAs can also be used in a more specialized way to monitor compliance with policies or regulation. One respondent to the Virginia survey indicated the UTCA was being used to "follow up on required landscape buffers that have deteriorated over time", thereby monitoring compliance with locality regulations. Periodic assessments can also be used to document increases in UTC as a means of addressing environmental regulation requirements on stormwater or air quality. Because of the ecological functions of UTC, including reducing stormwater runoff, sequential UTCAs could be used to prove UTC enhancement in areas prioritized to reduce stormwater runoff as a compliance measure with the Environmental Protection Agency's (EPA) Clean Water Act (Nowak 2006). Furthermore, strategically planted urban trees can count toward EPA's Clean Air requirements through voluntary and emerging measures of State Implementation Plans (SIPs) (U.S. EPA 2004). While 29% of CBW survey respondents noted that their locality used the UTCA to *demonstrate compliance with stormwater management goals or requirements (e.g., MS4s, WIP)*, only 2% said it had been used to *demonstrate compliance with air quality management goals or requirements (e.g. SIP)*. This may be because localities are not currently under scrutiny for their air quality or because using trees in SIPs is still evolving as an air quality compliance strategy.

3.4 Conclusions

To our knowledge, this is one of the first studies to investigate awareness and use of UTCAs by local governments across a broad geographic region. We chose the CBW for our study because there have been numerous UTCAs in the region as a result of the CBP identifying UTC as a key strategy for Bay restoration. While evaluating the CBP's progress on their goal of "120 communities with UTC expansion goals by 2020" was not within the scope of our study, we were able to systematically explore the prevalence of UTCAs and how they are being used in local urban forestry programs.

As of mid-2013, there were 55 assessments representing 101 towns, cities, or counties in the watershed with UTCA. Surprisingly, we found that one-third of the key respondents from localities where UTCAs had been performed were not aware that the UTCA existed. This indicates an opportunity for outreach to those smaller localities where a UTCA exists but the data have not been shared or an effort to provide the necessary technical assistance has not been made.

Furthermore, we found that even in localities aware of their UTCA, actual use of UTCA ranged from those not using it for any of the 17 pre-defined activities to those using it for all of them. We developed a conceptual model of general and specialized uses within the urban forestry planning model framework as described by Miller (1997), with the most frequently reported uses being the most general. The UTCA was used equally across stages of the urban forestry planning model: 49% UTC goal setting, 57% UTC implementation strategies, 49% UTC monitoring and evaluation. Localities reporting a specialized use were also performing the general use within the same stage. While most localities are using their UTCA to at least some extent, overall the tool appears to be underutilized.

This study demonstrates that there is potential to enhance the utility of UTCAs given the current limited awareness and limited use of these UTCA. Additional insight is needed regarding why some local governments use the UTCA more than others do in order to make the most effective investments in this tool. In the next chapter, we attempt to identify barriers to UTCA use and gain a more detailed understanding of the variability in use. Ultimately, continuing to increase overall awareness of both the existence and utility of UTCAs could pay important dividends and substantively improve the capacity of local urban forestry programs.

CHAPTER 4 PREDICTORS OF URBAN TREE CANOPY ASSESSMENT USE IN THE CHESAPEAKE BAY WATERSHED

4.1 Introduction

Over a decade ago, Dwyer et al. (2002) urged the development of tools to monitor and manage urban forests and associated economic, environmental, and social benefits. Since that time, there has been significant investment in urban forest management technology (Li et al. 2005; Young 2010). Advancements include enhanced urban forest remote sensing methods such as urban tree canopy assessment (UTCA) and analytical software like i-Tree tools (Kling 2008; Nowak 2013). However, little is known about the nature of use of these technologies by practitioners and local governments.

With this in mind, we studied the use of an emerging technology in urban forest management, UTCAs. Our target population was localities in the Chesapeake Bay watershed (CBW). The region is known to have a high concentration of UTCAs compared to the rest of the U.S. likely because of the role of urban tree canopy (UTC) management in large-scale environmental restoration and rehabilitation initiatives of the Chesapeake Bay.

The paper begins with a brief overview of UTCAs in the CBW and of information technology adoption. We then report on our study of UTCAs in the Chesapeake Bay watershed (CBW) in order to examine urban forestry technology adoption by local governments. First, we describe two methods for measuring UTCA adoption, one of which is creating user typologies based on the nature of use. We then describe the relationship between locality and urban forestry program characteristics and UTCA adoption to identify barriers and drivers of adoption. The results are described in the context of targeting outreach and technical assistance. The paper concludes with comments on the role of UTCAs in urban forest management and the potential for user typologies to improve targeted assistance to localities with UTCA.

4.1.1 Urban Tree Canopy Assessments in the Chesapeake Bay Watershed

UTCAs can be used to inform decisions about urban forest management (McGee et al. 2012; Locke et al. 2013). Conducting a UTCA entails analysis of high-resolution (1 meter or less) aerial or satellite imagery to identify where UTC exists and where there is potential for additional UTC (Walton et al. 2008; Lehrbass and Wang 2010; McGee et al. 2012). UTCAs can be combined with other data such as parcel boundaries or zoning classifications to generate information on the spatial distribution of UTC relative to land ownership or land use (Rodbell and Marshall 2009; McGee et al. 2012).

Dozens of UTCAs have been performed across the U.S. in recent years (USDA Forest Service 2013). There has been particular investment in UTCAs in the Chesapeake Bay watershed (CBW) because of the potential for UTC to reduce stormwater runoff and thus reduce nutrient and sediment pollution into the Bay (Goetz et al. 2004; Raciti et al. 2006; USDA Forest Service 2012). In fact, the Chesapeake Bay Program (CBP) has identified enhancing UTC as a key strategy for Bay restoration and has established a target of 120 communities with tree canopy expansion goals by 2020 (USDA Forest Service 2012).

In the previous chapter, we found that as of mid-2013 55 UTCAs existed covering 101 localities (counties, cities, and towns) within the CBW. Our findings indicated there were a range of uses for those UTCAs and not all localities were using their UTCA or even aware of it. A clear need derived from this work is to better understand why some localities are aware of and using UTCAs and others are not. Because UTCAs offer key benefits but often are under-utilized, a clear understanding of the reasons why would help increase use and prioritize additional investments.

4.1.2 Information Technology Adoption in Local Government

Since Rogers first published his seminal theory, the Diffusion of Innovations (DOI), in the early 1960's, there has been extensive research about how and why individuals and organizations adopt new tools and technologies and what variables influence their rate of adoption (Jeyaraj et al. 2006). Another relevant theory, the Technology Acceptance Model (TAM) was developed from research of adoption of computing technologies (Davis 1989). Recent investigation into adoption of geospatial information technologies by local governments includes inquiry related to use of platforms such as geographic information systems (GIS) (Merry et al. 2008; Göçmen and Ventura 2010) and planning support systems (PSS) (Vonk et al. 2005; Vonk et al. 2007). Vonk et al. (2006) provides a framework for understanding low levels of information technology adoption by examining PSS adoption in Dutch planning agencies. The framework examines bottlenecks in technology adoption from three perspectives: (1) the instrument approach; (2) the user approach; and (3) the transfer approach. In the instrument approach, the problem lies in a mismatch between the functionality of the technology and the needs of the potential user. In the user approach, there is a problem or blockage in the adoption process, and in the transfer approach, the problem is in the diffusion of information about the technology.

Social scientists have developed numerous models and theories to help understand the adoption process and predict whether a potential adopter will decide to adopt or reject a technology such as DOI and TAM. Adoption models often include numerous predictive variables. In a review of information technology adoption predictors, Jeyaraj et al. (2006)

categorized 135 variables related to user adoption into four main groups: technology characteristics such as perceived usefulness or data characteristics; individual characteristics such as age or computer experience; organization characteristics such as organization size or user training, and environmental characteristics such as external pressure or culture.

From the final perspective, transfer approach, the problem relates to a limited flow of information about the technology. The approach considers diffusion of a technology as a whole, related to the concept of a technology adoption curve (Figure 5) (Rogers 2003). In the technology adoption curve, adopters are characterized based on when they adopt a technology: early innovator, early adopter, early majority, late majority, and laggards. If a technology is under-used, the adoption may be in the early stages and communication about the technology may be limited. Furthermore, a change agent can increase the rate of adoption by facilitating the spread of information about a technology. For our purposes, a change agent could be an organization such as the CBP or a state's Urban and Community Forestry program. It is not inevitable that given enough time a technology will achieve widespread adoption. Some technologies simply fail—they are not used and are forgotten.

There is limited research on urban forestry technology adoption, particularly use of UTCAs as a planning and management tool. Information about how and why UTCA are being used by practitioners is important for designing technical assistance outreach. We need to know how localities are using the tool before designing outreach programs so that the content and audience is appropriate and targeted. Furthermore, understanding how UTCA use is related to locality and urban forestry program characteristics may help prioritize future investments in UTCAs towards localities that are most likely to employ them.

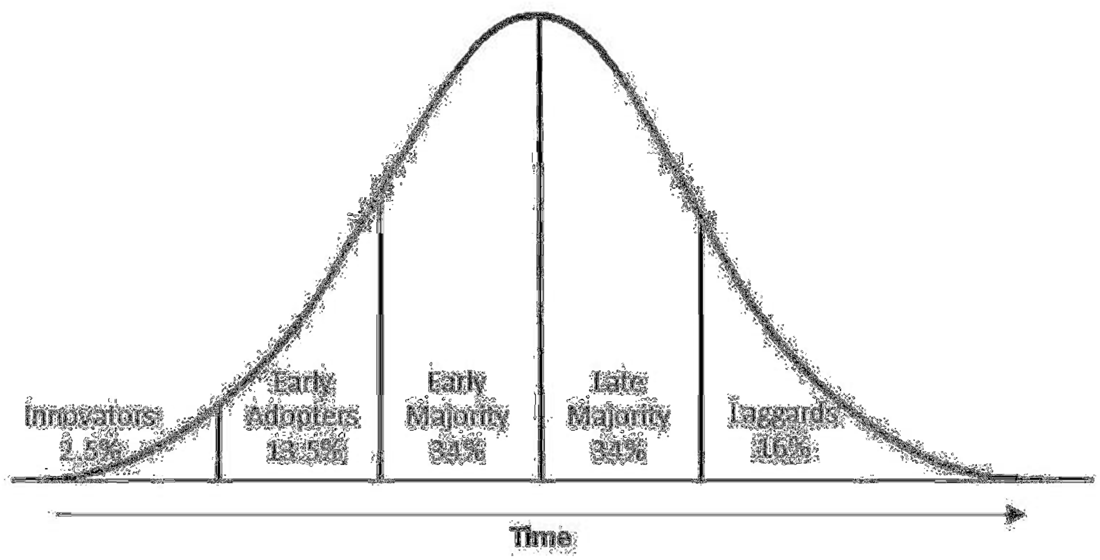

Figure 5 The technology adoption curve showing the normal distribution of the theoretical adoption of a technology through time (Rogers 2003).

4.2 Methods

4.2.1 Survey Design

A quantitative web-based survey (Qualtrics, Provo, UT) of 101 localities in the CBW known to have a UTCA as of May 2013 was conducted during July 2013. Twelve counties, 42 cities, and 47 towns completed the population frame and represented 9.2% of land area within the CBW.

Surveys were completed by a locality representative identified either through a web search of locality staff or by contacting the locality via telephone. To confirm qualification, identified representatives were contacted via telephone to discuss experience and willingness to participate. Representatives included urban foresters, arborists, municipal planners, and municipal managers.

Prior to administering the survey, a draft was pilot tested with several urban forestry professionals to identify and correct ambiguities and refine questions. To maximize the response rate, an introduction email requesting participation, an email with the survey link, and a follow-up reminder were sent to qualified representatives (Dillman 2000). The survey was organized into five sections (Table 4) with an initial screening question, “Are you aware of a UTCA for your locality?” If the respondent answered “No”, they skipped Sections 1 through 3 and responded only to measures in Section 4.

Table 4 Organization of the Chesapeake Bay watershed (CBW) survey and types of questions administered to all localities with populations >2,500 in the CBW known to have an urban tree canopy assessment (UTCA).

Section	Category	Types of questions
1	Characteristics of the locality’s UTCA	Who performed the UTCA? What year was it completed? How was it initiated?
2	Uses of the locality’s UTCA	Yes/No/Don’t Know response to 17 pre-defined activities:
3	Perceived usefulness of the locality’s UTCA	Categorical response (very useful; somewhat useful; not useful; not sure) for same 17 pre-defined activities
4	Characteristics of the locality’s urban forestry program	Level of staffing; funding; management plan; tree inventory; tree planting program; tree board; GIS capacity; UTCA training

4.2.2 Survey Analysis

4.2.2.1 Measures of Urban Tree Canopy Assessment Adoption

For survey analysis, we excluded one of the activities (*demonstrate compliance with air quality management goals*) because only one locality responded positively. To analyze survey data, two measures of UTCA adoption were developed: use score and user typology. To calculate the UTCA use score for each locality, “Yes” responses for the 16 pre-defined activities measured in Section 2 of the survey were summed (Table 4). Possible scores ranged from 0 to 16. Chronbach’s α was used to check internal consistency of the 16 measures. Chronbach’s α coefficient ranges from 0 to 1 with higher values indicating greater internal consistency between multiple items; a value of 0.70 is typically considered acceptable (Santos 1999). The coefficient for our UTCA use score was acceptable ($\alpha = 0.88$).

The UTCA user typology was created with two-step cluster analysis in SPSS (IBM Corp., Armonk, NY). The analysis was confined to the 34 localities that stated they were aware of their UTCA and answered questions about its use. Cluster analysis is iterative and sorts objects into groups using associated data (Shih et al. 2010; StatSoft 2013). In this study, localities were clustered based on UTCA uses and resulting typologies are grounded in data rather than predetermined groups.

We used log-likelihood distance measure and conducted the analysis several times, splitting respondents by specifying two, three, four, and five cluster solutions. Five clusters provided an acceptable fit, a mostly even distribution of respondents across cluster categories, and the most meaningful results for interpretation. Localities that were unaware of their UTCA were not included in the analysis and instead categorized as Non-Users.

4.2.2.2 Predictor Variables

We examined the relationship between our measures of UTCA adoption (use score and user typology) and other variables related to the locality, urban forestry program, and UTCA. Demographic data about each locality was collected from the U.S. Census Bureau and included population, land area, median household income, percent of adults with a college degree, homeownership rate, and percent of persons below the poverty level. Urban forestry program variables were selected following criteria for evaluating and scoring urban forestry programs proposed by Kenney et al. (2011). The criteria are broad measures that evaluate success and development of an urban forestry program (Table 4). UTCA characteristics were gleaned from UTCA reports where available and survey responses (Table 4, Sections 1 and 3).

4.2.2.3 Statistical Analyses

Statistical analysis was performed using JMP Pro Version 10 (SAS Institute Inc., Cary, NC). To determine the relationship between two categorical variables, we used Fisher's Exact Test, which determines the statistical significance of correlation between two categorical variables with small sample sizes in place of a χ^2 test (McDonald 2009). We also used bivariate correlation to identify relationships between two continuous variables. For categorical independent and continuous dependent variables we used the non-parametric Kruskal-Wallis test due to issues with non-normal distribution and unequal variance. Kruskal-Wallis test is an extension of the Wilcoxon Rank Sums test for three or more groups with the null hypothesis being that all groups are from the same population (Schlotzhauer 2007). All significance testing was performed at α=0.05.

4.3 Results

4.3.1 Survey Response

In total, 51 surveys were completed and analyzed representing 9 counties, 24 cities, and 18 towns. Only 34 localities reported they were aware of their UTCA. No response bias at the 95% confidence level was observed with respect to state, locality type, or population size. Responding localities represented about 7% of the total land area of the CBW and 81% of the total land area where UTCAs were known to exist.

4.3.2 Predictors of Urban Tree Canopy Assessment Use Score

4.3.2.1 Locality Characteristics

For our first measure of UTCA adoption, we summed each locality's 'Yes' responses for all 16 pre-defined uses queried in the survey to generate a use score, which ranged from 0 to 16. The mean use score was 5.5 for all 51 localities. The only significant correlates of UTCA use score were locality population (p=0.0002)and locality type (p=0.0190) (Table 5). Higher UTCA use scores were associated with larger populations. Similarly, counties had the highest use score (mean=8.33; SE=1.71), while towns had the lowest (mean=2.89; SE 1.21). Since population and locality type are not independent, e.g. cities and counties are typically bigger than towns, there may be an interaction between the two variables. We did not find any significant relationships between UTCA use score and state or any other locality demographics such as percent of college graduates, homeownership rate, percent of persons below the poverty level and median household income.

Table 5 Summary of p-values for statistical relationship between urban tree canopy assessment (UTCA) use score and all locality, urban forestry program, and UTCA variables tested. Count of localities (n) included in the analysis varies due to some missing values. * Significant at α=0.05.

	Variable	n	P-value
Locality Characteristics	Population size*	51	0.0002
	Locality type*	51	0.0190
	State	51	0.0891
	Land area	51	0.1289
	Percent college graduates	49	0.1470
	Median household income	50	0.2891
	Percent below the poverty level	50	0.5588
	Population density	51	0.7697
	Home ownership rate	50	0.8868
Urban Forestry Program Characteristics	Management plan*	51	0.0015
	Staffing*	51	0.0038
	GIS expertise*	50	0.0142
	Tree planting program	51	0.0603
	Tree board	51	0.0630
	UTCA workshop training	51	0.0826
	Funding	50	0.6118
	Inventory	51	0.6943
UTCA Characteristics	Year of UTCA*	41	0.0013
	Mean perceived usefulness [1]	34	0.1266
	Who performed UTCA	32	0.3249
	How UTCA was initiated	33	0.3352

[1] Mean perceived usefulness is for all 16 activities combined for each locality. Responses for perceived usefulness were recoded as: very useful=1; somewhat useful=0.5, not useful=0.

4.3.2.2 Urban Forestry Program Characteristics

We also tested the relationship between characteristics of the urban forestry program and the UTCA use score (Table 6). Based on the Kruskal-Wallis test, we found a significant relationship between use score and staffing level (p =0.0038), urban forest management plan (p=0.0015), and GIS expertise (p=0.0142). Use score significantly increased with higher levels of urban forestry staffing, when a comprehensive urban forest management plan existed, and with higher levels of GIS expertise. Surprisingly, we found no significant difference in UTCA use score with different funding levels or participation in UTCA workshop training. However, we did not ask questions about the content or duration of workshop training, which may explain why there was no significant relationship.

4.3.2.3 Urban Tree Canopy Assessment Characteristics

The only significant relationship between characteristics of the UTCA and its associated use score was the year that the UTCA was conducted (p=0.0013). The older the UTCA was, the higher the use score was within our range of years from 2008 to 2013. There was also no relationship between use score and mean perceived usefulness. However, for each of the 16 pre-defined use activities, the localities currently using the UTCA for a particular activity had a higher mean perceived usefulness for that activity than those not currently using the UTCA for that activity (Table 7).

Table 6 Count of localities, mean use score and standard error (SE) for localities based on responses to Chesapeake Bay watershed survey questions about the locality's urban forestry program. * Significant at α=0.05.

Urban Forestry Program Characteristics		Count of Localities	Mean Use Score[1]	SE
Variable	**Locality Survey Response**			
Urban Forest Management Plan*	1) There is a comprehensive urban forest plan that has been accepted and implemented	5	12.40	2.19
	2) There is a comprehensive urban forest plan pending acceptance and implementation	5	8.80	2.19
	3) There is an existing urban forest plan but it is limited in scope and implementation	14	4.93	1.31
	4) There is no urban forest management plan	27	3.96	0.94
Staffing*	1)There is a multi-disciplinary team (arborist, planner, landscape architect, GIS specialist, etc.) for addressing urban forestry issues	8	10.63	1.69
	2) There are professional arborists or foresters on staff with regular professional development	13	7.08	1.33
	3) There are urban forestry staff, but they have no specialized training or professional credentials	4	0.25	2.40
	4) There are no urban forestry staff	26	4.00	0.94
GIS Expertise*	1) We have expert GIS capacity in-house	24	7.92	1.04
	2) We have some in-house GIS capacity	13	4.00	1.42
	3) We have no in-house GIS	13	3.08	1.42
Tree Planting Program	Yes	30	6.93	0.96
	No	21	3.52	1.15
Tree Board	Yes	36	6.36	0.89
	No	15	3.53	1.39
Workshop Training	Yes	14	7.36	1.44
	No	37	4.84	0.89
Funding	1) There is adequate funding to sustain and maximize our urban forest benefits	8	7.50	1.94
	2) There is only enough funding to support management of our current urban forest	11	4.18	1.66
	3) There is insufficient funding to support management of our current urban forest	31	5.35	0.99
Tree Inventory	1) There is a current inventory of street trees and other public trees	2	7.00	3.95
	2) There is a current inventory of street trees	7	7.57	2.11
	3) There is an outdated inventory	15	5.53	1.44
	4) No tree inventory exists	27	4.89	1.07

[1] Use score calculated for each locality by summing 'Yes' responses for each of 16 pre-defined activities. Mean use score is the average for localities self-identifying with a particular response for each urban forestry program variable.

Table 7 Mean perceived usefulness and standard error (SE) by localities using and not using the urban tree canopy assessment (UTCA) for each of 16 pre-defined activities. * Significant at α=0.05.

Type of activity	Locality Use of UTCA for the Activity		Mean Perceived Usefulness [1]	SE
	Response	Count		
Plan and prioritize tree plantings*	Yes	23	0.93	0.05
	No	11	0.59	0.07
Plan and prioritize tree canopy conservation*	Yes	13	0.92	0.06
	No	21	0.74	0.05
Plan and prioritize outreach to specific neighborhoods*	Yes	16	0.88	0.08
	No	18	0.64	0.07
Create a locality-wide tree canopy goal*	Yes	24	0.96	0.05
	No	10	0.65	0.08
Develop tree canopy goals based on land-use or zoning	Yes	13	0.69	0.10
	No	21	0.57	0.08
Baseline for evaluating progress toward tree canopy goals	Yes	25	0.94	0.05
	No	9	0.83	0.08
Evaluate potential impacts of tree canopy gains or losses	Yes	16	0.78	0.08
	No	16	0.66	0.08
Leverage additional funding or justify funding requests*	Yes	17	0.85	0.06
	No	16	0.63	0.06
Enforce tree ordinances or site development requirements	Yes	10	0.55	0.11
	No	22	0.32	0.07
Educate public about the importance of tree canopy	Yes	29	0.81	0.05
	No	5	0.60	0.12
Inform creation or revision of policies	Yes	14	0.64	0.09
	No	19	0.55	0.07
Guide requirements for tree conservation during development *	Yes	12	0.67	0.09
	No	21	0.33	0.07
Inform land use planning and zoning with green infrastructure	Yes	16	0.59	0.08
	No	18	0.56	0.07
Inform larger initiatives	Yes	22	0.80	0.05
	No	11	0.68	0.08
Engage the public with local urban forestry*	Yes	15	0.83	0.06
	No	18	0.50	0.06
Demonstrate compliance with stormwater management goals*	Yes	15	0.73	0.08
	No	15	0.47	0.08

[1] **Responses recoded as follows: Very useful=1; somewhat useful=0.5; not useful=0; and 'not sure' was left blank.**

4.3.3 Segmenting Localities into User Typologies

Localities were clustered using a two-step cluster analysis into five user typologies based on their responses to survey questions about UTCA use (Table 8). Localities that reported that they were unaware that a UTCA existed were not included in the cluster analysis and were instead categorized separately as Non-Users. Using Fisher's exact test, we found that user typology was significantly correlated with locality population (p=0.0004), locality type (p=0.0028), urban forestry staffing (p=0.0092), and urban forest management plan (p=0.0493). Along with these significant relationships, other interesting trends were observed for each user type (Table 9).

4.3.3.1 Comprehensive Users

Comprehensive Users represent 9.8% of localities and reported using the UTCA for most or all of the 16 pre-defined uses. Comprehensive Users exist only in Maryland and Virginia in medium to large cities and counties. Urban forestry programs are most developed in Comprehensive Users; the majority reported having a multi-disciplinary urban forestry team and an urban forest management plan either already implemented or pending implementation. Furthermore, all localities in this type have a municipal tree planting program; most have a tree board and an experienced in-house GIS analyst. Additionally, of all the user types, Comprehensive Users most frequently reported someone within their locality having attended a workshop or training on UTCA.

4.3.3.2 Policy Focused Users

Policy Focused Users represent 11.8% of localities and are characterized by their use of the UTCA for all activities except those that require querying the UTCA data for in-depth prioritization (Table 8). Policy Focused Users are found mostly in Maryland and Virginia in cities and towns both small and large. Policy Focused Users typically have some elements of an urban forestry program, though on average it is not as well developed as Comprehensive or Prioritization Focused Users. The majority reported no urban forestry staff and the rest stated they have either professional urban foresters or arborists on staff. This group reported no urban forestry plan or one that is limited in scope and implementation. They typically have more complete tree inventories than any other group, two-thirds reported a tree planting program, and the majority has a tree board. Policy Focused Users have mixed GIS expertise—less than Comprehensive Users or Prioritization Focused Users—and mixed response to UTCA training. Interestingly, they reported *prioritizing canopy conservation* as one of the most useful potential activities but do not report using their UTCAs in such a way.

4.3.3.3 Prioritization Focused Users

Prioritization Focused Users are the second-largest group (19.6% of localities) behind Non-Users. They are characterized by using the UTCA for all activities except informing policies and land use planning activities (Table 8). These users are found throughout the CBW in cities and counties both small and large. Their urban forestry programs are somewhat developed with relatively strong staff capacity as compared to other types with either a multi-disciplinary urban forestry team or professional urban foresters or arborists on staff. Less than half have any type of urban forest management plan though, and none has a complete tree inventory. Most have a tree board and 70% have a tree planting program. As compared to other types, Prioritization Focused Users have the most GIS capacity (similar to Comprehensive Users), with more than 75% having expert in-house GIS capacity and the rest having at least some GIS expertise. They were the least frequent type (except Non-Users) to report staff having attended a UTCA workshop or training.

4.3.3.4 Basic Users

Basic Users represent 15.7% of localities and use the UTCA only for the most general activities. These users are found throughout the CBW representing all locality types and across all sizes of communities. Basic Users vary widely in development of their urban forestry programs. Half of the group reported urban forestry staff with regular professional development and the other half reported no urban forestry staff. None of the Basic Users have a comprehensive urban forest management plan implemented, but a quarter have a plan pending acceptance and implementation and another quarter have a plan that is limited in scope and implementation. Only 25% of this group have a tree planting program – the least of any group, though the majority have a tree board. Interestingly, localities in this type are not currently engaged in the UTCA activities they say are most useful: *prioritizing outreach to neighborhoods based on canopy cover* and *leveraging additional funding*.

4.3.3.5 Uninformed Users

This type of UTCA users represent 9.8% of localities and reported that they do not know how the UTCA is used, but that they are aware that it exists. All localities in this group are small or medium cities located throughout the CBW. This type has limited development of their urban forestry programs. They have the least staffing capacity of any type with more than 75% reporting no urban forestry staff. They also reported the lowest levels of funding and their urban forest management plans are either non-existent or limited in scope and implementation. Fewer than half have a tree planting program or a tree board. Half have expert in-house GIS expertise and another quarter have some in-house GIS expertise.

4.3.3.6 Non-Users

This group was not categorized into a typology using cluster analysis because they indicated in the survey that they are not aware of a UTCA for their locality. They represent 33.3% of localities and are mostly small and medium cities and towns across the CBW. While most localities in this group reported no urban forestry staff, there is a wide range of staffing capacity. The majority of this group does not have an urban forest management plan. Around 60% reported a municipal tree planting program and tree board, further showing the variability of this group. Additionally, this group has less GIS capacity than any of the UTCA user typologies; the majority has no GIS staff. Finally, Non-Users are the least likely to have had someone from their locality attend a UTCA workshop or training.

Table 8 Locality user types clustered based on responses to pre-defined uses of their urban tree canopy assessment (UTCA).

Potential uses of a UTCA in urban forest policy, planning, and management		Comprehensive User	Policy Focused User	Prioritization Focused User	Basic User	Uninformed User[1]
General Activities	Create a locality-wide tree canopy goal	Yes	Yes	Yes	Yes	DK
	Plan and prioritize tree plantings	Yes	Yes	Yes	Yes	DK
	Educate public about the importance of tree canopy	Yes	Yes	Yes	Yes	DK
	Inform larger initiatives	Yes	Yes	Yes	Yes	DK
	Provide a baseline for tree canopy goals	Yes	Yes	Yes	Yes	DK
Policy Activities	Inform land use planning and zoning with appropriate green infrastructure considerations	Yes	Yes	No	No	DK
	Guide requirements for tree conservation during site development and re-development	Yes	Yes	No	No	DK
	Inform creation or revision of policies such as zoning, taxation, tree ordinances	Yes	Yes	No	No	DK
	Enforce tree ordinances or site development requirements	Yes	Yes	No	No	DK
Prioritization Activities	Plan and prioritize tree canopy conservation	Yes	No	Yes	No	DK
	Plan and prioritize outreach to specific neighborhoods	Yes	No	Yes	No	DK
	Develop tree canopy goals based on land-use, zoning or other fine-scale criteria	Yes	No	Yes	No	DK
Other Specialized Activities	Engage the public with local urban forestry	Yes	Yes	Yes	No	DK
	Leverage additional funding or justify funding requests	Yes	Yes	Yes	No	DK
	Evaluate potential impacts of tree canopy change	Yes	Yes	Yes	No	DK
	Demonstrate compliance with air quality management goals or requirements (e.g. SIP)	Yes	Yes	Yes	No	DK
	Demonstrate compliance with stormwater management goals or requirements (e.g. MS4s, WIP)	Yes	Yes	Yes	No	DK

[1] Uninformed Users comprised localities that were aware that a UTCA existed, but did not know if or how it was being used (DK = don't know)

Table 9 Characteristics of urban tree canopy assessment user types with responses for each user type by percent (and count).

Characteristic		Comprehensive Users	Policy Focused Users	Prioritization Focused Users	Basic Users	Uninformed Users	Non-Users
Percent (and count) of localities		9.8% (5)	11.8% (6)	19.6% (10)	15.7% (8)	9.8% (5)	33% (17)
Locality size [1]		Medium to large	Small to large	Small to large	Small to large	Small to medium	Small to medium
Locality type		County, City	City, Town	City, County	Mixed	City	City, Town
Staffing	1) Multi-disciplinary urban forestry team	**60% (3)**	0% (0)	**40% (4)**	0% (0)	0% (0)	6% (1)
	2) Professional urban forestry staff	20% (1)	33% (2)	**40% (4)**	**50% (4)**	20% (1)	6% (1)
	3) Untrained urban forestry staff	0% (0)	0% (0)	0% (0)	13% (1)	0% (0)	18% (3)
	4) No trained urban forestry staff	20% (1)	**67% (4)**	20% (2)	**38% (3)**	**80% (4)**	**71% (12)**
Management plan	1) Have comprehensive management plan	**40% (2)**	17% (1)	20% (2)	0% (0)	0% (0)	0% (0)
	2) Comprehensive plan pending	**40% (2)**	0% (0)	0% (0)	**25% (2)**	0% (0)	6% (1)
	3) Have limited management plan	20% (1)	**50% (3)**	20% (2)	**25% (2)**	40% (2)	24% (4)
	4) No management plan	0% (0)	**33% (2)**	**60% (6)**	**50% (4)**	**60% (3)**	**71% (12)**
GIS	1) Expert in-house GIS	**80% (4)**	**50% (3)**	**80% (8)**	**50% (4)**	**40% (2)**	18% (3)
	2) Some in-house GIS	20% (1)	17% (1)	20% (2)	**25% (2)**	**20% (1)**	**35% (6)**
	3) No GIS	0% (0)	**33% (2)**	0% (0)	**25% (2)**	**20% (1)**	**47% (8)**
Tree inventory	1) Current inventory of all public trees	0% (0)	17% (1)	0% (0)	0% (0)	0% (0)	6% (1)
	2) Current inventory of street trees only	20% (1)	17% (1)	20% (2)	25% (2)	0% (0)	6% (1)
	3) Outdated inventory	20% (1)	**33% (2)**	**30% (3)**	13% (1)	**60% (3)**	29% (5)
	4) No inventory	**60% (3)**	**33% (2)**	**50% (5)**	**63% (5)**	40% (2)	**59% (10)**
Funding	1) Adequate funding to optimize urban forest	20% (1)	17% (1)	20% (2)	13% (1)	0% (0)	18% (3)
	2) Just enough funding to maintain urban forest	20% (1)	17% (1)	10% (1)	**38% (3)**	40% (2)	18% (3)
	3) Insufficient funding	**60% (3)**	**67% (4)**	**60% (6)**	**50% (4)**	**60% (3)**	**65% (11)**
Tree planting		Yes (100%)	Yes (67%)	Yes (70%)	No (75%)	No (60%)	Yes (59%)
Tree board		Yes (80%)	Yes (83%)	Yes (80%)	Yes (88%)	No (60%)	Yes (59%)
UTCA training		Yes (60%)	No (67%)	No (70%)	No (63%)	No (60%)	No (94%)

[1]**Small localities (2,500 – 49,999 people); medium localities (50,000 – 99,999); large localities (100,000 or greater)**

4.4 Discussion

To inform targeted outreach and technical assistance to localities in the CBW, we examine our results in the context of the framework by Vonk et al. (2006) to explain low levels of UTCA use. In the first of Vonk et al.'s three approaches to technology adoption – the innovation approach – the problem lies with the technology itself not adequately meeting the user's needs. We measured perceived usefulness of the UTCA for all pre-defined activities and found that perceived usefulness was lower for localities not using the UTCA for a particular activity than for those localities using it. This could suggest that localities not using the UTCA for a certain activity believe that the UTCA does not match their needs for that activity. Mustonen-Ollila and Lyytinen (2003) found users' recognition of a technology as being appropriate for their task to be one of the most important factors influencing technology adoption. Targeting this barrier may involve localities that are successfully using the UTCA sharing their experiences about how they have used their UTCA. Alternatively, there may be instances where the UTCA is not the best tool for a certain activity and therefore should not be promoted as such.

We measured several variables pertaining to the adoption process relevant in Vonk et al.'s user approach. We found relationships between advanced use of a UTCA and some urban forestry program variables such as staffing level or the existence of an urban forest management plan. One challenge in this research was that we used an individual respondent as a proxy for a locality's behavior. For many localities, especially small ones, there may only be one or two people responsible for making decisions about UTCA use. However, in larger localities, there are many different potential users of a UTCA and each staff member goes through the adoption process separately, deciding whether to adopt or reject the UTCA. Therefore, each potential user's personal characteristics, which we did not measure, may influence their decision or ability to use the tool.

Overall, our research suggests that advanced use of UTCA was related to larger and more developed urban forestry programs. However, it is not clear whether a well-developed urban forestry program leads to more in-depth use of UTCA, or if vice versa, more in-depth use of UTCA can help develop an urban forestry program. Several researchers have found that locality size is related to the development of an urban forestry program, with smaller communities often lacking trained staff, adequate funding, or other elements of a successful program (Schroeder et al. 2003; Kuhns et al. 2005). On the other hand, a number of the potential uses of UTCA – such as *leveraging additional funding*, *informing tree policy and ordinances*, *public outreach about the importance of UTC*, *prioritization of tree plantings,* and *creating UTC goals* – are all aspects of sustainable urban forest management (Kenney et al. 2011). Therefore, it is possible that urban and community forestry programs are maturing concurrently with the use of UTCA and that UTCA could be a key catalyst to program maturation.

We were surprised that we did not find a significant relationship between UTCA workshop training and advanced use of UTCA. However, we did not measure the quality of the training or subject matter covered. Moreover, because we only had one respondent from each locality, their individual knowledge about training activities may have been incomplete. We were also surprised that our location variable, state, did not significantly differ in level of UTCA use because we had hypothesized that differences in priorities of each state's Urban and Community Forestry Program and different state level regulations would have an impact on usage.

From the transfer approach perspective of Vonk et al.'s framework, the problem lies with the flow of information about the technology to potential users. By the very fact that one-third of localities were unaware of their UTCA, we illustrate that this is one of the limiting aspects of UTCA use. Most of these localities also do not have urban forestry staff and therefore may not be included in current communication channels about UTCA amongst state and local agencies. One recommendation would be to expand the group of individuals targeted for information about UTCA to urban planners or even to city or town managers in localities that do not have specific urban forestry staff. Additionally, expounding on the potential applications of UTCA for planners and managers may be effective for engaging this wider audience. Change agents such as the CBP or a state's Urban and Community Forestry program can play an important role in the rate of diffusion of information about UTCAs and potentially their use.

Furthermore, we found that age of the UTCA was significantly related to advanced UTCA use, indicating that localities that had their UTCA longer were using them in more advanced ways. These results are consistent with the theory of Rogers (2003), who posits that adoption of technology follows a normal distribution through time; we surmise from our findings that adoption of UTCA as an urban forestry tool by localities in the CBW is in its early stages.

In order for the CBP to achieve its goal of 120 communities with canopy expansion goals by 2020, our recommendation is that future UTCA investment be prioritized toward localities that fit our Comprehensive User typology. These include large localities, especially counties, which already have an urban forestry program and would therefore be able to utilize UTCA information most effectively. For localities where a UTCA already exists, outreach and technical assistance should be targeted. For example, Uninformed Users and Non-Users may initially need to be notified that a UTCA exists and informed about its potential uses, particularly targeting a broader group such as planners or city managers. Information about the potential use of UTCA should be available in a format that is accessible to decision-makers, planners, and ordinary citizens because in many of these localities there is no in-house GIS staff or urban forestry program to target.

Basic Users, on the other hand, may benefit from learning about how more advanced users, including Comprehensive Users, Policy Focused Users, and Prioritization Focused Users, have used their UTCA or from more user-friendly manipulation of the data that does not require GIS expertise. We found that Basic Users considered the UTCA activity *prioritize outreach to neighborhoods based on canopy cover* and *leverage additional funding* to be the most useful, but are not actually using them this way. This suggests that there are additional barriers to these activities.

While we have shed light on a few variables that are related to UTCA use by localities in the CBW, there are likely other important variables. For example, other potential factors could include characteristics of the individuals who responded to the survey on behalf of their locality and their interest and willingness to use the UTCA or encourage others to do so.

4.5 Conclusions

With the underlying assumption that UTCAs can be translated into actions resulting in UTC conservation, it is imperative that practitioners in local government have the knowledge and capacity to use existing UTCAs. Ultimately, to the extent that UTCAs are not translated into action, urban tree canopy conservation is not reaching its full potential in the CBW. To address this, we identify some drivers and barriers to UTCA use by practitioners and propose a user typology approach to targeting localities for outreach and technical assistance about UTCAs.

This is one of the first studies on use of technology adoption specific to urban forestry and therefore more in-depth research is needed to more fully understand localities motivations for using these technologies and expectations of the technologies.

In this study, we found larger locality size and urban forestry program sophistication to be significantly related to advanced use of a UTCA. This finding suggests that such localities are better equipped to use a UTCA for urban forest management. However, it is possible that urban and community forestry programs are maturing concurrently with the advancement in use of UTCA. Moreover, UTCAs are not the only tools available and localities may be using a different tool that better suits their needs.

Additionally, we segmented localities into UTCA user typologies based on their reported UTCA use and found a number of differences between user types and urban forestry program characteristics. These differences provide insight not only to developing more targeted technical assistance but also for selecting for future investment in UTCAs. Based on the high proportion of localities unaware of their UTCA and the fact that many localities are only using the tool at a very basic level, we believe that one of the major bottlenecks is in the dissemination of information about UTCAs. Substantial gains could be made by increasing the rate of adoption of UTCAs with the continued dissemination of information and facilitation of information sharing by change agents such the CBP and state Urban and Community Forestry programs.

Our study has investigated only a few of the numerous potential variables affecting UTCA adoption by localities in the CBW and hopefully future research can build upon what we have found. UTCA are a recent technology in early stages of adoption but they are perceived by users as highly useful tools. Therefore investment should continue for performing UTCAs and in expanding awareness and training for practitioners in localities with an existing UTCA in the hope that these actions will translate to urban canopy conservation and enhancement in the CBW.

CHAPTER 5 CONCLUSION

5.1 Summary

In this study, we investigated the existence of UTCAs for urban localities within the CBW and examined the various ways in which practitioners are using UTCAs for informing UTC goals, developing management strategies to achieve those goals, and monitoring of progress. Through further analysis, we delved deeper to empirically relate the ways in which a locality uses its UTCA with variables such as characteristics of the locality, its urban forestry program, and its UTCA. We also identified some barriers to UTCA adoption and provided some recommendations to overcome those barriers to enhance use of UTCAs by local government practitioners.

As of mid-2013, we found 55 UTCAs covering 101 localities in the CBW. Of the 51 surveys that were completed and submitted, we found that 33% of localities were not aware that a UTCA existed for their locality. Even though this represents a substantial proportion of the population, we found evidence that at least one other locality was using the UTCA in cases where it covered multiple localities. UTCAs were used for a variety of activities which we organized based on Miller's urban forestry planning model.

Overall, we found larger localities with more sophisticated urban forestry programs and resources used their UTCAs in a greater number of ways. We also found that localities that had their UTCA for more time were using it in a greater number of ways suggesting that it takes time to integrate the tool. Surprisingly, we did not find a significant relationship with number of uses and having a staff member attend a UTCA workshop or training. In addition, we developed user typologies by clustering localities based on the nature of use of their UTCA. These user types could inform targeted outreach and technical assistance to localities struggling to implement their UTCA.

5.2 Research Limitations

A major limitation of this study is that survey questions are subject to perceptual bias. Despite our efforts to reduce ambiguity by pre-testing our survey instruments, respondents may have interpreted questions differently than intended. An additional complication is that several of our questions were subjective. If we were to have asked questions that are more objective about actual dollar amounts budgeted to various uses, we may have been able to identify relationships that are more sensitive.

An effort was made to balance depth of information gathered with the survey instrument and realistic expectations of respondents' time investment in completing the survey. Our measures for level of use of a UTCA were also general in nature. For example, we asked whether the UTCA had ever been used for an activity. However, there is a lot of potential variability of frequency of use, depth of use, and how institutionalized the process is, all of which we did not measure. Therefore, our results should be viewed as an exploratory study and should be followed up by in-depth interviews with practitioners to gain a more complete understanding of UTCA use.

Lastly, though our results may have some application for UTCAs conducted outside the CBW, our findings are exclusively based on localities in this region. Therefore, other studies must be conducted in other areas of the country to develop a global understanding of UTCA use and usefulness as perceived by local governments.

5.3 Research Implications

In this research, we set out to empirically evaluate how practitioners in local government are using UTCAs. As a new tool for urban forest resource assessment it is important to evaluate if intended users are realizing its potential. We have found that UTCAs are in fact being used by localities large and small across the CBW for a variety of purposes. Our results suggest that there are opportunities to expand the use of existing UTCAs by raising awareness about their existence and including municipal planners and managers in the targeting of that information. Furthermore, we recommend formalized information sharing between localities about how they are employing their UTCAs.

With continuing population growth and increasing urbanization pressures, managing our urban forest resource is of paramount importance. We must continue to make our cities healthy and sustainable places to live. Resource assessment is the first step in urban forest management and UTCAs are a new tool for resource assessment.

We propose that change agents such as a state's Urban and Community Forestry Program or the CBP can help overcome some bottlenecks in the adoption of UTCAs by increasing the rate of diffusion about UTCAs and their potential values and uses. It is important to identify the role that these change agents play in the use of UTCAs. This research enhances the ability for change agents to target outreach to localities and thus expand UTCA use hopefully resulting in urban forest management decisions informed by UTCAs that will lead to a more sustainable and resilient future.

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APPENDIX A: CHESAPEAKE BAY WATERSHED SURVEY POPULATION

List of 101 localities in the Chesapeake Bay watershed with an urban tree canopy assessment (UTCA) as of May 2013.

State	Name of Locality	Administrative Unit	Population (2010)	Area (km^2)	UTCA Area
DC	District of Columbia	district	617,996	159	District of Columbia
DE	Georgetown	town	6,422	11	Town of Georgetown
DE	Harrington	city	3,562	5	City of Harrington
DE	Laurel	town	3,708	4	Town of Laurel
DE	Middletown	town	18,871	17	Town of Middletown
DE	Seaford	city	6,928	9	City of Seaford
MD	Aberdeen	city	14,959	18	Harford County
MD	Annapolis	city	38,394	19	City of Annapolis
MD	Anne Arundel County	county	537,656	1,077	Anne Arundel County
MD	Baltimore City	independent city	620,961	210	Baltimore City
MD	Baltimore County	county	805,029	1,551	Baltimore County
MD	Bel Air	town	10,120	8	Harford County
MD	Berwyn Heights	town	3,123	2	Prince George's County
MD	Bladensburg	town	9,148	3	Prince George's County
MD	Bowie	city	54,727	48	City of Bowie
MD	Brentwood	town	3,046	1	Prince George's County
MD	Brunswick	city	5,870	8	City of Brunswick
MD	Capitol Heights	town	4,337	2	Prince George's County
MD	Chestertown	town	5,252	7	Chestertown
MD	Cheverly	town	6,173	3	Prince George's County
MD	Chevy Chase	town	2,824	1	Montgomery County
MD	College Park	city	30,413	15	Prince George's County
MD	Cumberland	city	20,859	26	City of Cumberland
MD	District Heights	city	5,837	2	Prince George's County
MD	Frederick	city	65,239	57	City of Frederick
MD	Gaithersburg	city	59,933	26	Montgomery County
MD	Glenarden	city	6,000	3	Prince George's County
MD	Greenbelt	city	23,068	16	City of Greenbelt
MD	Hagerstown	city	39,890	31	City of Hagerstown
MD	Harford County	county	243,085	1,140	Harford County
MD	Havre de Grace	city	12,952	14	Harford County
MD	Howard County	county	287,085	653	Howard County
MD	Calvert County	county	88,944	557	Calvert County
MD	Hyattsville	city	17,557	7	City of Hyattsville
MD	Laurel	city	25,115	11	Prince George's County
MD	Montgomery County	county	971,777	1285	Montgomery County
MD	Mount Rainier	city	8,080	2	Prince George's County

State	Name of Locality	Administrative Unit	Population (2010)	Area (km^2)	UTCA Area
MD	New Carrollton	city	12,135	4	Prince George's County
MD	Poolesville	town	4,883	10	Montgomery County
MD	Prince George's County	county	863,420	1257	Prince George's County
MD	Riverdale Park	town	6,956	4	Prince George's County
MD	Rockville	city	61,209	35	City of Rockville
MD	Seat Pleasant	city	4,542	2	Prince George's County
MD	Takoma Park	city	16,715	5	City of Takoma Park
MD	University Park	town	2,548	1	Prince George's County
PA	Akron	borough	4,046	3	Lancaster County
PA	Archbald	borough	6,984	44	Scranton Metro Area
PA	Blakely	borough	6,564	10	Scranton Metro Area
PA	Clarks Summit	borough	5,116	4	Abingtons
PA	Columbia	borough	10,400	6	Columbia Borough
PA	Denver	borough	3,332	3	Lancaster County
PA	Dickson City	borough	6,070	12	Scranton Metro Area
PA	Dunmore	borough	14,057	23	Scranton Metro Area
PA	East Petersburg	borough	4,450	3	Lancaster County
PA	Elizabethtown	borough	11,887	7	Lancaster County
PA	Ephrata	borough	13,394	4	Lancaster County
PA	Jessup	borough	4,676	17	Scranton Metro Area
PA	Lancaster City	city	59,322	19	City of Lancaster
PA	Lancaster County	county	519,445	2,458	Lancaster County
PA	Lititz	borough	9,029	6	Lancaster County
PA	Manheim Borough	borough	4,858	4	Manheim Borough
PA	Marietta	borough	2,689	2	Lancaster County
PA	Millersville	borough	7,774	5	Lancaster County
PA	Moosic	borough	5,719	17	Scranton Metro Area
PA	Mount Joy	borough	6,765	6	Lancaster County
PA	New Holland	borough	5,092	5	Lancaster County
PA	Old Forge	borough	8,313	9	Scranton Metro Area
PA	Olyphant	borough	5,151	14	Scranton Metro Area
PA	Scranton	city	76,089	65	Scranton Metro Area
PA	State College	borough	42,034	12	State College Borough
PA	Strasburg	borough	2,800	3	Lancaster County
PA	Taylor	borough	6,263	13	Scranton Metro Area
PA	Throop	borough	4,088	13	Scranton Metro Area
VA	Arlington County	county	207,627	67	Arlington County
VA	Ashland	town	7,225	19	Town of Ashland
VA	Charlottesville	independent city	43,475	27	City of Charlottesville
VA	Chesapeake	independent city	222,209	907	City of Chesapeake
VA	Fairfax County	county	1,081,726	1,023	Fairfax County
VA	Fredericksburg	independent city	24,286	27	City of Fredericksburg

State	Name of Locality	Administrative Unit	Population (2010)	Area (km^2)	UTCA Area
VA	Front Royal	town	14,440	25	Town of Front Royal
VA	Herndon	town	23,292	11	Fairfax County
VA	Leesburg	town	42,616	32	Town of Leesburg
VA	Lexington	independent city	7,042	6	City of Lexington
VA	Luray	town	4,895	12	Town of Luray
VA	Lynchburg	independent city	75,568	127	City of Lynchburg
VA	Manassas	independent city	37,821	26	City of Manassas
VA	Newport News	independent city	180,719	180	City of Newport News
VA	Norfolk	independent city	242,803	139	City of Norfolk
VA	Portsmouth	independent city	95,535	90	City of Portsmouth
VA	Purcellville	town	7,727	8	Town of Purcellville
VA	Richmond	independent city	204,214	156	City of Richmond
VA	Vienna	town	15,687	12	Fairfax County
VA	Virginia Beach	independent city	437,994	642	City of Virginia Beach
VA	Waynesboro	independent city	21,006	40	City of Waynesboro
VA	Winchester	independent city	26,203	24	City of Winchester
VA	Woodstock	town	5,097	8	Town of Woodstock
WV	Berkeley County	county	104,169	834	Berkeley County
WV	Charles Town	city	5,259	15	Jefferson County
WV	Jefferson County	county	53,498	544	Jefferson County
WV	Martinsburg	city	17,227	17	Berkeley County
WV	Ranson	city	4,440	21	Jefferson County

APPENDIX B: CHESAPEAKE BAY SURVEY RESPONSES

Responses to the Chesapeake Bay watershed survey questions on aspects of the localities' urban forestry programs; data given in percent (and count) of respondents for all 51 survey respondents.

Urban Forestry Program Capacity	% (Count)	
Staffing		
There is a multi-disciplinary team	**16%**	(8)
There are professional arborists or foresters on staff with regular professional development	**25%**	(13)
There are urban forestry staff, but they have no specialized training or professional credentials	**8%**	(4)
There are no urban forestry staff	**51%**	(26)
GIS Expertise		
Expert GIS in-house	**47%**	(24)
Some GIS in-house	**25%**	(13)
No GIS in-house	**25%**	(13)
No response	**2%**	(1)
Funding		
There is adequate funding to sustain and maximize our urban forest and urban forest benefits	**16%**	(8)
There is only enough funding to support management of our current	**22%**	(11)
There is insufficient funding to support management of our current urban	**61%**	(31)
No Response	**2%**	(1)
Management Plan		
There is a comprehensive urban forest plan that has been accepted and is being implemented	**10%**	(5)
There is a comprehensive urban forest plan pending acceptance and implementation	**10%**	(5)
There is an existing urban forest plan but it is limited in scope and implementation	**27%**	(14)
There is no urban forest management plan	**53%**	(27)
Inventory		
There is a current inventory of street trees and other public trees	**4%**	(2)
There is a current inventory of street trees only	**14%**	(7)
There is an outdated inventory	**29%**	(15)
No tree inventory exists	**53%**	(27)
Does the locality have…	**Yes**	**No**
…a municipal tree planting program	**59%** (30)	**41%** (21)
…a tree commission	**71%** (36)	**29%** (15)
…someone who has attended a training or workshop on UTCAs	**27%** (14)	**73%** (37)

APPENDIX C: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: June 21, 2013

TO: Eric Wiseman, Pulelehua L Kimball

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)

PROTOCOL TITLE: Chesapeake Bay Urban Tree Canopy Assessment Implementation

IRB NUMBER: **13-536**

Effective June 21, 2013, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the New Application request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Exempt, under 45 CFR 46.110 category(ies) 2**
Protocol Approval Date: **June 21, 2013**
Protocol Expiration Date: **N/A**
Continuing Review Due Date*: **N/A**
*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

Date*	OSP Number	Sponsor	Grant Comparison Conducted?
06/21/2013	13017807	VA Department of Forestry	Not required (Exempt approval)

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

APPENDIX D: CHESAPEAKE BAY WATERSHED SURVEY INTRODUCTION EMAIL

Date: July 8, 2013
Subject: Survey Participation Request - Urban Tree Canopy Assessment Research

Dear Participant,

You are receiving this email because your locality is located within the Chesapeake Bay Watershed and has an urban tree canopy assessment according to information provided by the Urban and Community Forestry Program for your state and the Chesapeake Bay Partnership.

As a graduate student at Virginia Tech, I am conducting research to understand how localities within the Chesapeake Bay watershed are using urban tree canopy assessments.

Urban tree canopy (UTC) is the layer of tree leaves, branches, and stems that cover the ground of urbanized areas when viewed from above. A UTC assessment uses high-resolution aerial photography in combination with remote sensing and GIS techniques to generate and analyze land cover data for a locality. The data can be used to support natural resource planning, management, policy, and education by identifying existing tree canopy cover and opportunities to enhance the urban forest.

We request your locality's voluntary participation in a short web survey that will be sent to you later this week. This survey research will help advance our understanding of UTC planning and management. It will also help guide future development of UTC outreach and technical assistance programs in the region. Even if you do not believe your locality has a UTC assessment, your participation in this survey is vital to the success of our research.

If you feel that there is someone else in your locality who would be more appropriate to complete this survey, please send me their contact information. For more information about UTC assessments, visit: http://www.nrs.fs.fed.us/urban/utc/.

Please keep an eye out for the survey you will be receiving later this week.

If you require additional information or have questions, contact me at lelekim@vt.edu.

Sincerely,
Lele Kimball

APPENDIX E: CHESAPEAKE BAY WATERSHED SURVEY EMAIL

Date: July 16, 2013
Subject: Urban Tree Canopy Assessment Survey Link

Dear Participant,

Last week I contacted you by email to introduce myself and request your voluntary participation in a short web survey about your locality's use of its urban tree canopy (UTC) assessment.

I invite you to participate in the survey by clicking here.

Your survey responses are important. If you are unsure of any answers, you may wish to consult with others in your locality to answer them completely and accurately. Even if you do not believe your locality has a UTC assessment, your locality's participation is vital to the success of this research.

The survey should take approximately 15-20 minutes to complete. Your responses are confidential and you can stop the survey at any time without prejudice. To resume the survey, simply click on the link in this email. Please complete and submit the survey by Friday, July 26th or let me know if you need more time.

If you require additional information or have questions, contact me at lelekim@vt.edu.

Sincerely,
Lele Kimball
Graduate Student
Department of Forest Resources and Environmental Conservation
College of Natural Resources and Environment
Virginia Tech
lelekim@vt.edu

APPENDIX F: CHESAPEAKE BAY WATERSHED SURVEY REMINDER EMAIL

Date: July 29, 2013
Subject: Reminder--Please Complete the Urban Tree Canopy Assessment Survey

Dear Participant,

Please remember to complete this urban tree canopy (UTC) assessment survey. Even if you do not believe your locality has a UTC assessment, your locality's participation is vital to the success of this research.

I know your schedule is busy so we've decided to keep the survey open a little longer. It will now be available until the end of the day, Wednesday, August 7th.

I invite you to participate in the survey by clicking here.

Your survey responses are important. If you are unsure of any answers, you may wish to consult with others in your locality to answer them completely and accurately.

The survey should take approximately 15-20 minutes to complete. Your participation is voluntary, your responses are confidential, and you can stop the survey at any time without prejudice. To resume the survey, simply click on the link in this email. Please complete and submit the survey by Wednesday, August 7th or let me know if you need more time.

If you require additional information or have questions, contact me at lelekim@vt.edu.

Sincerely,
Lele Kimball
Graduate Student
Department of Forest Resources and Environmental Conservation
College of Natural Resources and Environment
Virginia Tech
lelekim@vt.edu

APPENDIX G: CHESAPEAKE BAY WATERSHED SURVEY

Introduction
Virginia Tech's Department of Forest Resources and Environmental Conservation is conducting this survey to understand how localities within the Chesapeake Bay watershed are using urban tree canopy (UTC) assessments for land use planning, targeted tree planting projects, and greenspace conservation.

Your responses to this survey are confidential, voluntary, and will contribute to our understanding of how and why UTC assessments are used as decision-support and resource management tools.

- Urban tree canopy (UTC) is the layer of tree leaves, branches, and stems that cover the ground of urbanized areas when viewed from above.
- A UTC assessment uses high resolution imagery in combination with remote sensing and GIS techniques to generate and analyze land cover data for a locality. The data is used to support natural resource planning, management, policy, and education by identifying existing tree canopy and opportunities to conserve and enhance urban forests.
- A decision support tool, such as a UTC assessment, helps organizes information to support planning and prioritization, leading to more informed decision making.

Please answer all questions to the best of your ability.

Screening Questions
Q1) Select your state and locality type.
- o DE
- o DC
- o MD
- o PA
- o VA
- o WV

- o Town
- o Borough
- o City
- o County
- o District

Q2) Are you aware of a UTC assessment for your locality? (It may be part of a larger county-wide assessment.)
- o Yes
- o No

Urban Tree Canopy (UTC) Assessment
Q3) What year was the UTC assessment for your locality completed?____________

Q4) How was the UTC assessment initiated for your locality?
- o We were approached by our state's Urban and Community Forestry Program
- o Our locality contracted a private company to complete the UTC assessment

- Our locality was assessed as part of a larger project area without our request
- Our locality responded to a grant or cost-share opportunity through our state's Urban and Community Forestry Program or the Chesapeake Bay Program
- Other _____________
- Don't Know

Q5) Who conducted the UTC assessment?

- University of Vermont Spatial Analysis Laboratory
- Virginia Geospatial Extension Program at Virginia Tech
- Locality staff
- State Urban and Community Forestry Program
- Private company (list if you are willing to disclose)________________
- Other _____________________-
- Don't Know

Uses of UTC Assessment

Q6) We'd like to understand how your locality uses the UTC assessment. Select whether or not your locality has ever used the information from the UTC assessment for each task listed below (Yes, No, Don't Know)

1. Plan and prioritize tree plantings
2. Plan and prioritize tree canopy conservation
3. Plan and prioritize outreach to specific neighborhoods or districts based on tree canopy cover
4. Create a locality-wide tree canopy goal
5. Develop tree canopy goals based on land-use, zoning or other fine-scale criteria
6. Provide a baseline for evaluating progress toward tree canopy goals
7. Evaluate potential impacts of tree canopy gains or losses
8. Leverage additional funding or justify funding requests
9. Demonstrate compliance with air quality management goals or requirements (e.g. SIP)
10. Enforce tree ordinances or site development requirements
11. Educate public officials or citizens about the importance of tree canopy
12. Inform creation or revision of policies such as zoning, taxation, tree ordinances
13. Guide requirements for tree conservation during site development and re-development
14. Inform land use planning and zoning with appropriate green infrastructure considerations
15. Inform larger initiatives (e.g. sustainability plans, watershed implementation plans, green infrastructure plans, comprehensive plans)
16. Engage the public with local urban forestry (e.g. volunteer recruitment, partnerships).
17. Demonstrate compliance with stormwater management goals or requirements (e.g. MS4s, WIP)

Q7) Is there anything you would like to add about how your locality uses the UTC assessment?

Perceived Usefulness of UTC Assessment

Q8) We'd like to understand how useful you believe that the UTC assessment could be for each task listed below. Drag and drop each item on the left to the box on the right that best matches your belief (very useful, somewhat useful, not useful, not sure). Be sure to move all items on the left to one of the four boxes on the right.

Items

1. Plan and prioritize tree plantings
2. Plan and prioritize tree canopy conservation
3. Plan and prioritize outreach to specific neighborhoods or districts based on tree canopy cover
4. Create a locality-wide tree canopy goal
5. Develop tree canopy goals based on land-use, zoning or other fine-scale criteria
6. Provide a baseline for evaluating progress toward tree canopy goals
7. Evaluate potential impacts of tree canopy gains or losses
8. Leverage additional funding or justify funding requests
9. Demonstrate compliance with stormwater or management goals or requirements (e.g. MS4s, WIP)
10. Demonstrate compliance with air quality management goals or requirements (e.g. SIP)
11. Educate public officials or citizens about the importance of tree canopy
12. Inform creation or revision of policies such as zoning, taxation, tree ordinances
13. Guide requirements for tree conservation during site development and re-development
14. Inform land use planning and zoning with appropriate green infrastructure considerations
15. Inform larger initiatives (e.g. sustainability plans, watershed implementation plans, green infrastructure plans, comprehensive plans)
16. Engage the public with local urban forestry (e.g. volunteer recruitment, partnerships)
17. Enforce tree ordinances or site development requirements

Perceived Constraints

Q9) We'd like to understand the actual or potential constraints to your locality using the UTC assessment. Identify each item listed below as a constraint or not a constraint by dragging it to the appropriate box. **Rank constraints with 1 being the most significant constraint**. Order is not important in the "Not a Constraint" box. Be sure to **move all items** to one of the two boxes.

Items

1. Lack of political will
2. Lack of financial resources
3. Lack of staff time
4. Appropriate state or national level policies or regulation not in place
5. Current UTC assessment not of sufficient quality (e.g. age, resolution)
6. Lack of communication/ coordination within local government
7. Limited awareness of usefulness of UTC assessment tool
8. Lack of staff expertise

Q10) Is there anything you would like to add about constraints to your locality using its UTC assessment?

Urban Forestry Program

Just a few more questions about the context of urban forestry in your locality

Q11) Select the statement that best describes the current staffing level of the urban forestry program for your locality.

1) There is a multi-disciplinary team (arborist, planner, landscape architect, GIS specialist, etc.) for addressing urban forestry issues
2) There is a multi-disciplinary team (arborist, planner, landscape architect, GIS specialist, etc.) for addressing urban forestry issues
3) There are urban forestry staff, but they have no specialized training or professional credentials
4) There are no urban forestry staff

Q12) Select the statement that best describes the funding for urban forestry in your locality.

1) There is adequate funding to sustain and maximize our urban forest and urban forest benefits
2) There is only enough funding to support management of our current urban forest
3) There is insufficient funding to support management of our current urban forest

Q13) Select the statement that best describes the urban forest management plan in your locality.

1) There is a comprehensive urban forest plan that has been accepted and is being implemented
2) There is a comprehensive urban forest plan pending acceptance and implementation
3) There is an existing urban forest plan but it is limited in scope and implementation
4) There is no urban forest management plan.

Q14) Select the statement that best describes the inventory of trees in your locality's urban forest (Not including the UTC assessment).

1) There is a current inventory of street trees and other public trees
2) There is a current inventory of street trees only
3) There is an outdated inventory
4) No tree inventory exists

Q15) Does your locality have a municipal tree planting program?

- Yes
- No

Q16) Does your locality have a tree board or tree commission?

- Yes
- No

Q17) What level of GIS expertise does your locality possess?

- We have no in-house GIS
- We have some in-house GIS capacity
- We have expert GIS capacity in-house

Q18) Have staff from your locality been trained or attended a workshop on how to use UTC assessment data?

- Yes
- No

Q19) Is there any additional information you would like to add about your locality's urban forestry program?

Section 6: Demographics
Q20) What is your gender?

- Female
- Male

Q21) What is your age?

- <25
- 26-35
- 36-45
- 46-55
- 56-65
- >65

Q22) What is the title of your current position? ________________

Q23) How many years have you been in your current, or a similar, position with the locality? ___________

Q24) Are you willing to be contacted for additional information?

- Yes
- No

Q25) Is there any additional information you would like to add to your survey response?

You have reached the end of the survey. By clicking "Next Page" you will submit your responses.